Impact of Traffic Emission on Air Quality in A Developing City of Nigeria

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Abstract

Minna is a developing city that lies between the Sahel and Guinea Savanna regions of Nigeria, and occupies a land area of 490 ha. Its population has increased from 70,000 in 1979 to over 300,000 in 2000. This increase has been attributed to a number of reasons such as nearness to the federal capital city of Nigeria and economic growth. During the period, the number of motor vehicles in the city increased by 400%. Although an increase in the motor vehicles eases the movement of people and goods, it could lead to an increase in traffic emission, which would constitute environmental and health hazards. A micro-scale analysis of the pollutants on a busy road in the city was studied during the dry season. A piston hand gas pump with detector tubes was used to sample CO, NO_2, SO_2, and CO_2. Only traces of NO_2 and SO_2 were detected. The concentration of CO detected was as high as 15 ppm, which is a little lower than the Federal Environmental Protection Agency limit of 20 ppm, and was attributed to vehicle emission. In addition, the CO_2 concentration was as high as 5000 ppm, which is still below the maximum level stipulated by the United States Environmental Protection Agency, but was not due to traffic emission alone. Thus the city is not under the threat of traffic pollution. This finding could serve as base-line information for urban development vis-à-vis traffic management policy in Nigeria.

Keywords: *Motor vehicle, air pollution, traffic management, urban development.*

Introduction

Air pollution is defined as the contamination of air by discharge of harmful substances, which can cause health problems including burning eyes and nose, itchy irritated throat and breathing problems (USEPA 1994). It was also reported that some chemicals found in polluted air could cause cancer, birth defects brain and nerve damage, and long-term injury to the lungs and breathing passages in certain circumstances. The concentrations of such chemicals beyond a limit, and an exposure over a certain period are extremely dangerous and can cause sever injury or even death.

Air pollution can be classified into natural air pollution which includes wind blown dust, volcanic ash, and gases, smoke and trace gases from forest fires, and anthropogenic air pollution which includes products of combustion such as nitrogen oxides (NO_x), carbon oxides (CO_x), sulphur dioxide (SO_2). Indeed, motor vehicles produce more air pollution than any other single human activity (WRI 1992). Nearly 50% of global CO, hydrocarbon, and NO_x emissions from fossil fuel combustion come from gasoline- and diesel-powered engines. In the city centers, especially on highly congested streets, traffic can be responsible for as much as 90–95% of the ambient CO levels, 80–90% of the NO_x and hydrocarbons, and a large portion of the particulates, posing a significant threat to human health and natural resources (Savile 1993).

Air pollution problem has been well documented in Europe and the US with motor vehicles being the main contributors. In Europe and the US, Small and Kazimi (1995) reported that motor vehicles emission account for 32–98% of national emissions of CO, volatile organic compounds (primarily hydrocarbons) and NO_x. Furthermore, Cline (1991) stated that transportation accounts for an important fraction of green house gases (especially CO_2) emission.

USEPA (1993) reported that transportation sources were responsible for 77% of CO emissions, 45% of NO_x, 36% of volatile organic compounds, and 22% of particulates in the US during the year 1993. In the European Union, pollution control measures have been initiated over the past 20 years to reduce NO_2 levels, but these measures have been offset by increases in the numbers of vehicles on the road (CEC 1992). In the UK, for example, average concentrations of NO_2 increased from 1986 to 1991 by 35%, mainly as the result of increased emissions by motor vehicle traffic (UK/DOE 1992). In the developing world, automotive air pollution is mostly a problem in large cities with high levels of traffic, such as Mexico City, Bangkok, and Lagos, Nigeria. In other cities, power plants, factories, and other stationary sources still constitute the greatest threat to air quality. However, even in some smaller urban centers such as Peshawar, Pakistan, and Katmandu, Nepal, air pollution from motor vehicles is becoming an increasing problem (UK/DOE 1992).

The impacts of motor vehicle emissions extend far beyond the local area. The transportation sector is the most rapidly growing source of greenhouse gas emissions--that is, emissions of chemicals that have the potential to contribute to global warming (IPCC 1995). These include CO_2, chlorofluorocarbons, NO, and CO. In 1990, about 22% of CO_2 emissions from fossil fuel use came from the transportation sector. OECD countries are responsible for about 70% of greenhouse gas emissions attributed to transportation. However, the share of emissions from developing countries is expected to rise in the future because of the growing sizes of their motor vehicle fleets and their use of less efficient fuel-burning technologies (IPCC 1995).

Cities embody the diversity and energy of human pursuits. Urbanization brings about increases in population, which lead to corresponding increases in motor vehicles, either for private or for public transportation. The environmental costs of motor vehicle are hard to measure and vary according to local conditions. Health cost estimates from local air pollution in the Los Angeles region of the US in 1992 was reported by Small and Kazimi (1995) to be $0.03 per vehicle-mile. McCubbin and Delucchi (1997) corroborated this fact, and stated further that health cost as a result of truck emission could be as high as ten times that of cars and small buses. In both studies most of the health hazards are as a result of the increased mortality due to the presence of volatile organic compounds, NO_x and SO_x in the inhaled air. The rest of the hazards are due to minor illness from ozone (O_3), formed in the atmosphere from volatile organic compounds and NO_x.

Policy makers all over the world have been partially successful in improving air quality. In the US, the ambient levels of most pollutants have been reduced steadily since the 1960s (Calvert *et al.*, 1993, Harrington *et al*, 1995). Small and Kazimi (1995) reported that Europe has lagged behind the US in emission controls on motor vehicles. Africa is even worse off. In Nigeria, the government has banned the importation of vehicles over eight years old. Good as this policy may look like, what remains to be done is how to control emission from the existing old vehicles plying the streets and highways of Nigeria. Some of the policies are aimed at reducing overall vehicle use, so as to minimize congestion/or pollution. However, these policies really do little to reduce the twin effect of congestion and pollution. According to Hall (1995) the problem of congestion is specific to location and time, whereas emissions are specific to vehicle characteristics and driving behaviour. The diesel or petrol-fired electricity generator is also a source of air pollution, and it is contributing to the choking air in cities like Abuja and Lagos, which are plagued by daily smog shrouding the skyline of the central city. As Sub-Saharan African cities experience increased urbanization and motorization, air pollution, particularly from vehicles still using leaded gasoline, is worsening. By providing access to business and public facilities, urban transport plays a critical role in the development of urban areas and overall economic growth but it also generates a number of externalities in terms of accidents, noise, traffic congestion, and air pollution. The latter is becoming a major environmental and health concern in sub-Saharan Africa. High rate of urbanization (4–8% in a number of cities) expected to be sustained for the next decade, combined with low-income solutions to daily commuting, has resulted in the rapid increase in pollutants emitted by motorized vehicles.

The Study Area

Minna is the capital of Niger State, and it is 100 km from Abuja the Federal Capital City of Nigeria. Its climate lies between the Sahel and Guinea Savanna regions, and has two distinctive seasons (dry and wet). The dry season occurs between November and March while the rainy season is between April and October, with the peak rainfall in September.

The population of Minna was 60,000 in 1963, when the state was created. The population had increased to 122,031 in 1991 with a growth rate of 2.8% (Minna Master Plan 1979). There has not been a corresponding increase in industrial activities in the town. Major industries in the town include small agricultural processing industries, plastic manufacturing industries, confectioneries, pharmaceutical and surgical companies. On the other hand, there has been an increase in the number of vehicles for personal and commercial use in the town. Thus, traffic emission is expected to be a major source of air pollution in the town.

An area of Minna town with the most traffic congestion (Amogu 2001) was selected for this investigation. The selected site is located in the central business district of the town and it is congested during the morning hours of 7:30–9:30 a.m., when offices and commercial centres opened for business and 4:30–7:00 p.m. in the evening when the offices and business centres are closed. Traffic volume and activity is high on the two-lane dual carriageway road.

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Method of Investigation

The census of registered vehicles was obtained from the state licensing office. A questionnaire, which is aimed at determining the age of vehicles was prepared and administered on a sampled population (50 for private cars, 100 for motorcycles, 200 and 50 for commercial cars and buses). The sample size was based on earlier traffic studies in the area (Amogu 2001).

Vehicles were randomly chosen and with the permission of the drivers, the gas sampling pump and detector tubes were used to detect the prevalent gases from the exhaust fumes. A piston hand gas pump (RAE LP-1200 model) was used to determine the proportion of the gases as the car engines was started. The second process of sampling involved open-air sampling at the median of the highway, as well as 10 and 20 m away from the highway, which lies in the built-up area. Sampling was done at 2-min intervals with corresponding traffic volumes being recorded. In order to identify the maximum effect of traffic emission in the city, measurements were taken during the dry season (November and December), as Baumbach *et al.* (1995) had shown that traffic emission in Lagos is higher during *harmattan* season than during the rainy session. Traffic was counted and at intervals air was pulled into the pump and the concentration of the pollutant measured. The samplings were carried out on working days during traffic congestion periods.

Results and Discussion

Fig. 1 shows the variation in the age of motorcycles, private and commercial cars as well as buses, based on the questionnaire and information from the Federal Road Safety Corps. The figure shows that the age of over 90% of motorcycles is less than ten years. However, only 10% of commercial cars and 6% of buses fall within the same age group. Eighty per cent of buses and commercial cars are within the age group of 10–20 years. Most of the exhaust pipes of the vehicles are horizontal and discharge backward. It was difficult to obtain the age of some vehicles as the drivers were sceptical about the study. The older the vehicles, the higher the proportion of the pollutants emitted, indicating that commercial cars and buses are main contributor of traffic emission in Minna. The proportion of older vehicles in Minna, a developing city, agrees with other studies like Faiz *et al.* (1994) who reported that low income levels have been an incentive to import older used vehicles in recent years, to use cheap two-wheelers and cheap fuel, and to postpone vehicle maintenance. Such conditions result in an increase in the emissions per km travelled, slow speeds due to low investment in road maintenance and traffic management.

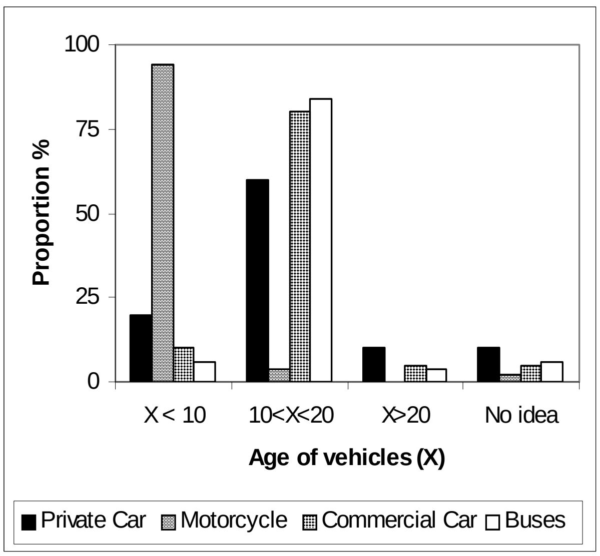

Fig. 1. Variation of age of vehicles in Minna

Table 1 shows the statistics of registered vehicles in the state licensing office. The table shows that a total of 7,967 private vehicles, 4,557 commercial vehicles and 9,145 motorcycles were registered between 1993 and 2001. The number of vehicles registered before 1995 was 3,002, and motorcycles accounted for 1,677. It could be deduced that 13.4% of the total motor vehicle population was registered before 1995. This result does not mean that the vehicles are less than ten years old because most of the vehicles are imported into the country as used vehicles. However, not all the vehicles registered in the city remain and are used in the city, many vehicles also migrate from other cities to Minna.

Table 1. Registered vehicle census

Year	Private	Public	Motor cycles	Trucks/ buses
1993	387	261	445	14
1994	620	375	880	20
1995	968	644	1113	43
1996	975	472	890	23
1997	1015	556	1025	14
1998	983	418	986	12
1999	1019	542	1313	26
2000	1045	621	1250	28
2001	955	455	1252	33

The pump and detector tubes were able to measure concentrations of CO and CO_2 and detect traces of SO_2 and NO_x. Fig. 2 shows the level of CO measured during the dry season. The CO emissions are higher at the median than within the built-up area (that is at 10 or 20m away from highway). The concentration of CO decreases with increase in the distance from highway. It also corroborates De Rosa (2003) assertion that traffic pollutants are higher in concentration at the roadside or median. De Rosa (2003) also reported that young and middle aged men serving as motorway tollgates attendants in Italy, subjected to exposure to traffic pollution have their fertility impaired. The maximum concentration of CO detected was 15 ppm, however, this is lower than the 48 ppm stipulated by the WHO and 20 ppm stipulated by the Federal Environmental Protection Agency (FEPA) of Nigeria. The level of CO measured is still within the safe limit, but roadside vendors are however, being threatened by some health hazards. For example, Greiner (1991) stated that CO is a slow poison that kills by reducing the oxygen supply in the body.

Fig. 3 shows the variation of CO_2 at the median as well as at 10m and 20 m away from the highway. There is no distinct pattern in the variation of CO_2 with distance from the highway. This is due to the fact that CO_2 is a product of combustion and respiration that can be produced domestically, as well as from industrial sources and motor vehicle emission. The maximum concentration of CO_2 was 5,000 ppm. This is less than the WHO stipulated maximum of 20,000 ppm. However, Greiner

(1991) reported that the presence of CO_2 concentration from 2500 to 5000 ppm, could cause headache, indicating that concentration of CO_2 within the study area is high enough to cause health hazard. However, the level of CO_2 measured could not be attributed to vehicle emission alone.

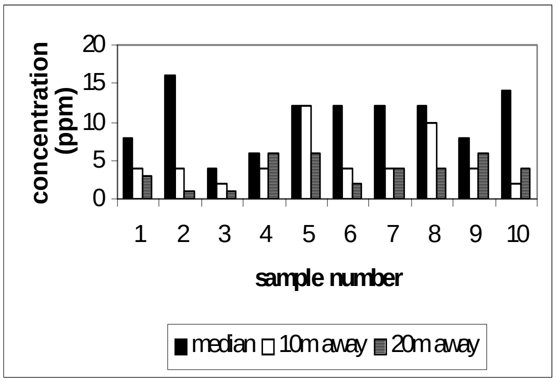

Fig. 2. Concentration of CO in the atmosphere

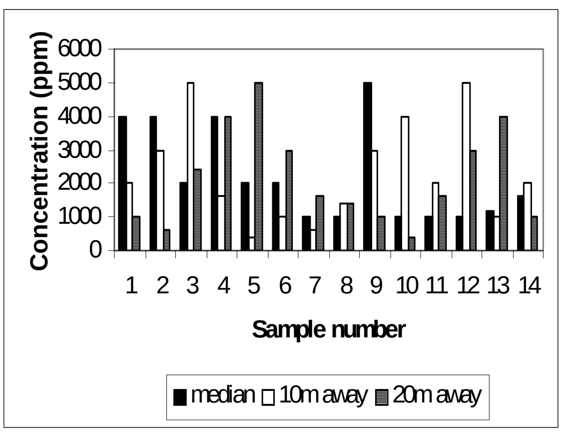

Fig. 3. Concentration of CO_2 in the atmosphere

Although the trends and sources of transport air pollution may somewhat vary between cities, the impact on the society are the same. Such impact includes health problems mostly for children and the poorest, reduction in productivity, poorer quality of life, and degradation of the environment. Thus, the results of this investigation could be summarized as follows:

1. Traffic emissions in Minna City include pollutants like carbon monoxide and carbon dioxide as well as traces of sulphur dioxide and nitrogen oxides.
2. The concentrations of the gases measured are still within the limits stipulated by the WHO and FEPA. This implies that traffic emission in Minna, which has a population of about 300,000 people with 3,000 vehicles, is within the safe limit.
3. The low pollution level may be attributed to the low industrialization level of the city, a higher proportion of non-polluting vehicles and the short congestion peak periods in the city.

Conclusion

Urban air pollution patterns may vary from one city to another depending on various factors, and pollutants need to be identified and quantified according to their potential sources.

References

Amogu, O. 2001. The relationship between geometric design features and roundabout performance in Minna. Unpublished B.Eng. project, Dept. Civil Eng., Federal University of Technology, Minna, Nigeria.

Baumbach, G.; Vogt, U.; Hein, K.R.G.; Oluwole, A.F.; Ogunsola, O.J.; Olaniyi, H. B.; and Akeredolu, F.A. 1995. Air pollution in a large tropical city with high traffic density – results of measurements in Lagos, Nigeria. Sci. Total Envt. 169: 25-31.

Calvert, J.G.; Heywood, J.B.; Sawyer, R.F.; and Seinfeld, J.H. 1993. Achieving acceptable air quality: some reflections on controlling vehicle emission. Science 261: 37-45.

Cline, W.R. 1991. Scientific basis for the greenhouse effect. Econ. J. 101: 904-919.

CEC. 1992. The State of the Environment in the European Community: Overview, Vol. 3. Commission of the European Communities, Brussels, Belgium.

De Rosa, M. 2003. Traffic pollution damages men’s sperm. J. Human Reprod. 18: 1055.

Faiz, A.; Sinha, K.; and Gautam, S. 1994. Air Pollution Characteristics and Trends. Discussion Paper, World Bank, Washington, DC, USA.

Greiner, T. 1991. Indoor air quality of CO and CO_2. Iowa State Univ. Extension Publ. No. AEN-125.

Hall, J.V. 1995. The role of transport control measures in jointly reducing congestion and air pollution. J. Transport Econ. Policy 29: 93-103.

Harrington, W.; Walls, M.A.; and McConnel, V.C. 1995. Shifting Gears: New Directions for Cars and Clean Air. Discussed Paper 94-26-REV Resources for the Future, World Bank, Washington, DC, USA.

IPCC. 1995. IPCC Synthesis Report of World Meteorological Organization, Intergovernmental Panel on Climate Change. UNEP, Geneva, Switzerland.

McCubbin, D.R.; and Delucchi, M.A. 1996. The social cost of the health effects of motor vehicle air pollution report II in the series: the annualized social cost of motor vehicle use in the U.S. based on 1990-1991 data, report UCD-ITS-RR-96-3. Institute of Transportation Studies, Univ. of California, Davis, CA, USA.

Minna Master Plan. 1979. The Capital City of Niger State, Final Report prepared by Max Lock Group, Nig. Ltd. Town Planning Division, Ministry of Housing and Environment, Niger State, Nigeria.

Saville, S. B. 1993. Automotive options and air quality management in developing countries. Indust. Envt. 16 (1-2): 20, 32.

Small, K..;A and Kazimi, C. 1995. On the costs of air pollution from motor vehicles. J. Transp. Econ. Policy 29: 7-32.

USEPA. 1993. Guide to Environmental Issues, Doc. No. 520/B-94-01 United States Environmental Protection Agency, Washington, DC, USA.

USEPA. 1994. National Air Quality and Emissions Trends Report, pp. 2, 6, 46, 52. United States Environmental Protection Agency, Washington, DC, USA.

UK/DOE. 1992. The UK Environment, pp. 17 - 21. UK Dept of the Environment, London, UK.

WRI. 1992. World Resources. World Resources Institute, in collaboration with the United Nations Environment Programme and the United Nations Development Programme. Oxford University Press, New York, NY, USA.