SURVEY OF AUTOMOBILE SMOKE EMISSIONS FOR ENVIRONMENTAL MANAGEMENT IN NIGEERIAN CITIES

Tanimowo N. B.

Department of Urban and Regional Planning
Faculty of Environmental Sciences
Ladoke Akintola University of Technology, P.M.B. 4000 Ogbomoso, Nigeria

ABSTRACT: This paper analyses the composition of automobile traffic in five Nigerian cities, namely Akure, Ibadan, Ilorin, Ogbomoso and Oyo. with respect to smoke emitted at different hours of the day time and the visual obstruction created, as well as the kind of automobile generating smoke as a pollutant. Findings of the study reveal that, more than half (i.e. 59.33%) of vehicles plying city roads emit visible smoke. On the average, every type of vehicle emits smoke. In terms of thickness of smoke emitted, trucks and motorcycles give the greater amount, but the lower volume comes from private and official vehicles whose smaller emission is possibly due to their relatively younger age and better maintenance. More smoke is observed in the ascending motion than the descending motion; carrying implication for people and buildings located along the hill slope. The findings call for more intensive control and monitoring of use, operation and maintenance of vehicles in cities. The findings also point out the need for more stringent transport policy as relating to environmental planning and management in cities. The study, being exploratory, is to stimulate further studies in the area of city transport and environmental pollution.

Key words: Automobile in cities; environmental pollution; vehicular smoke emission; traffic composition; smoke and visibility; monitoring and control of vehicular operation.

1. Introduction

The introduction and use of automobile in cities, which used to be pedestrian precincts before, were initially received with applause for their benefits. The use of vehicles in cities was later received with suspicion on ground of safety. At present however automobile in cities are re-assessed with awe for its environmental hazards. Transportation, generally, has become a significant source of air pollution.

Motor vehicles are the largest source of urban air pollution as they generate much carbon monoxide, nitrogen oxide and hydrocarbon which form smog in cities of developing countries. They emit toxic substances and other harmful compounds which are detrimental to human health. The vehicular emissions, particularly in the form of smoke and smog create visual obstruction and other aesthetic problems, which are hazardous to men and pets as they also lower values of properties.

Automobile is a potential degrader of urban environment. Its peculiar element as source of pollution is particularly underscored by its mobile nature. Automobile engines emit nitrogen dioxide as gas and fumes; smoke as aerosol; and, carbon monoxide and acids as vapour. Together with air pollution, the most conspicuous elements of nuisance constituted in residential areas are noise and vibration; pedestrian delay and the severance of communities; air pollution from exhaust and emissions; visual intrusion; risk of accidents and intimidation; and dirt and slush.

Attention to the problem began and kept increasing from the beginning of the 20th century until 1920s when as observed by Thomson (1977), that the environmental effects of motor vehicles in cities had elicited a protest everywhere except in developing countries. The comparative situation of cities in developed and developing countries is the fact that while people still hassle for city life in developing countries, decrease in city population in western

(developed) countries is caused less by growing demand for accommodation but more and mainly by resistance against living in an area of polluted air and unbearable noise.

The concern of students of urban safety and health about automobile-emitted pollution of city air keeps increasing as number and age of vehicles increase in developed countries. The experience of increasing vehicles and vehicle age is equally true today in Nigerian cities where numerous small vehicles are the interest of people and the fairly used or refurbished vehicles are imported into the country in the wake of economic downturn. The economic recession had reduced people's economic power to purchase new vehicles.

On the part of Nigerian government, attention to environment generally is not lacking. In the establishment and functions of Federal Environmental Protection Agency (FEPA), by decrees of 1988 and 1992 (FRN, 1988, 1992), and its subsequent replacement by National Environmental Standard Regulations and Enforcement Agency (NESREA) in 2007, interest in environmental protection is clear. FEPA itself issues guidelines for its standard performance (FEPA, 1991). National legal backing for environmental protection is also contained in the Urban and Regional Planning Decree 88 of 1992 (FRN, 1992). Yet attention to air pollution is still not adequate in the country and in particular, the ones directed at automobiles and city environment is still not much felt. This is due to the general *laissez faire* approach to urban vehicle use and maintenance.

In the definition of air pollution (Cooper Alley, 1986; Elson, 1987; Orusil, 1997) reference is consistently made to smoke as a substance of particulate nature emitted by automobile. Emphases are placed on its deleterious effect on the visibility, human safety and man-made property, particularly, in cities. Most studies on automobile emission identify two types with respect to air pollution in cities. One is gaseous, the other involves particulates. Smoke is prominent in the particulate type which is made up of aerosols, water droplets, tetraethyl lead, dust and black smoke. The particulate substance including smoke from automobiles have been subjected, for various reasons to laboratory and non-laboratory outdoor studies (van-Hassel et al, 1979; Fergussion et al, 1983; Olajire and Ayodele, 1996; Ganske, 2003).

A general description of research in this respect is copiously provided in literature. For example, Japan NTS and Environmental Laboratory (2003) give an overview of such studies. Also, US Environmental Protection Agency directs that quantity of emission should be taken at specified conditions such as distance per hour, at similar temperature, wind-speed or ground terrain ranges. The major objective of the studies is to assess the impact of automobile emission and to provide for the control of the same in cities.

The assessment of smoke alone as an element of emission is important as a result of the risk and the danger it constitutes to visibility and safety to men; and the deleterious effect it has on the aesthetic and economic value of property. Automobile-emitted smoke, viewed singly or with other elements, impair visibility, soils building materials, paints and surfaces and causes presence of objectionable odour. Smoke, depending on thickness or darkness, darkens lead-based white and bright colour paints. It also deteriorates fabrics. Smoke-dust accumulation devalues properties and also irritates eyes. Moreover, and most importantly, smoke reduces visibility that is essential and necessary for the automobile and other mechanical operations, leading often to accidents.

Smoke is so much about the most visible in vehicular nuisance in cities that Sharp and Jennings (1976) observe that up till 1976, visible smoke is the only air pollutant that received legislative control in Britain.

2. Study Objectives

The objective of this paper to reveal empirically the characteristics of the automobile emitted smoke in selected Nigerian cities in order to assess the magnitude of the environmental nuisance and danger constituted. The quasi-quantitative analysis of smoke emission from different vehicle types, at different times of the day and on different ground terrains can provide useful information for automobile control efforts and policies to improve urban liveability in developing countries.

3. Method of study

Two major streets through which various types of vehicle pass were selected in each of five towns sampled for the study. Where possible, streets notable for thorough traffic in the township, were the main choice for study. The cities in which the study took place were Ibadan, Oyo, Ilorin, Ogbomoso and Akure, all in the south-western Nigeria noted for its highest urbanization feature in the country.

Specially trained research assistants were made to observe the emission of different types of vehicles at cordon points selected. The cordon points were so selected to be on sloppy roads of reasonable gradient. The observations were recorded according to the scale rating of smoke thickness in the traffic count format.

The format for observation has hourly time of the day from 7am to 6.pm on the Y-axis and the types of vehicles on the X-axis. Rating of smoke emission from 1 to 5 is described in table 1 below.

The researchers were exposed to two methods of rating smoke as automobiles emission. The calibrated instrument used several times to observe smoke of different thickness to obtain different readings was used for the training. Secondly, the different grades of smoke pasted on cardboards were observed and given different grades on the scale of 1 - 5. These were to train the eyes of the personnel in the observation of thickness of smoke emitted by a vehicle. Admittedly, the method is qualitative. Chemical contents of the smoke emitted are not analysed, yet, it yields information sufficient to demonstrate some degree of thickness of the smoke generated as pollutant thrown into the air by various types of vehicles as observed in different places. The observation method like that of cloud cover of the sky rated by thickness has its value of sensitising people to the environmental danger of automobile emission. The relative colour effect of smoke can be attributed to various shades of grey colour with different values ranging from white to black. Value in colour scheme is usually considered in terms of a scale spanning from white(the lightest) to black (the darkest) with a number of degrees in between. For the purposes of detail analysis as contained in the Table 1, five different grades of value were selected varying from very light, light, average, thick, and very thick respectively. The rating figures were entered into the format as tallies as the smoke types were observed in the vehicle count.

Table 1: Differential Scale for Ranking of Visible Automobile Smoke Recorded

Smoke Rate	Corresponding colour scheme	Rating figure	Description
Very thick		5	Thick smoke that blocks the view and prevents entirely sighting of objects behind it.
Thick		4	Thick smoke that block the view but is lighter than the kind rated 5
Average		3	Smoke whose quantity prevents certainty of object behind it
Light		2	Smoke that is light enough but permit fair sighting of objects behind it.
Very light		1	Smoke visible but light enough to permit clear sighting of objects behind it

The figures obtained from each of the five cities were aggregated and were analysed representing observations from all the cordon points.

4. Smoke and General Pollutants from Automobiles

It is thus realized every vehicle emits gases particularly nitrogen oxide and aerosol such as fume and smoke. Smoke is visible and is indicative of the possible emission of other pollutants. Although smoke alone is not representative of different kinds of gases emitted by automobiles, however, its presence is visible to sensitize the general public to its nuisance by virtue of the visibility blocked and the mere dust raised.

Smoke emission is a function of several factors and these include age of vehicle, type of engine (petrol or diesel), form of engine (four stroke or two stroke), engine maintenance, type of oil used, etc. Details of these are outside the scope of the present study. The author uses smoke in mere descriptive study meant to sensitize public to air pollution and encourage further research in the issue of automobile smoke in urban air pollution.

5. Analyses and Findings

Table 2 shows the total number of vehicles with smoke as against those without smoke. It is shown that, on the whole, vehicles that emit visible smoke are 5815 representing 59.33% while those without visible smoke emission are 3986 representing 40.67% of the total. In effect, greater percentage of vehicles plying roads in the urban centres studied emit smoke and are potential sources of air and environmental pollution.

Worse still, urban air pollutants are classifiable into stationary and mobile, by the threat constituted to comfort, health, life and economy. There are stationary sources whose impacts are limited to point or area of emission. e.g. industrial premises. Automobiles as most important source of pollution are particularly dangerous for their mobility wherein they do not only emit pollutants but spread the same as they move about.

Table 2: Number and percentage of vehicles that emit visible smoke

Vehicles	No. Counted	%
Vehicles with visible smoke	5815	59.33
Vehicles without visible smoke	3986	40.67
Total	9801	100.00

Source: Authors fieldwork, 2005

Table 3: Visible Smoke Emission by Type of Vehicle as they Ascend or Descend the Slope

Vehicle type	Vehicle ascending	Vehicle descending	Total number of vehicle
Taxi cab	796	693	1489
Bus	330	289	619
Private car	605	601	1206
Truck	617	604	1221
Motorcycle	612	608	1220
Official cars	30	20	50
Others	09	01	10
Total	2999 (52%)	2816 (48%)	5815

Source: Authors fieldwork, 2005

Table 2 and 3 show the number of vehicles counted at cordon points selected in the cities from 7:00 am to 6.pm. The vehicles counted as emitting smoke are 5815 (59.33%). Those emitting smoke are further analysed in Table 3. 2999 (52%) of them are ascending the slope while 2816 (48%) are descending. In effect, the tables demonstrate the composition of vehicles passing through fairly busy major streets in the cities studied. In the cities, taxi cabs top the list while official cars and other types of vehicle have negligible figures.

Two salient points that are relevant to this study are reflected in the table. One of these is the preponderance of trucks passing through the city streets either as carriers of freight for urban use or as through traffic to industrial areas or other cities. The other is the prevalence of commercial motorcycle as new development in automobile use in Nigerian cities. Each of them accounts for about 20% of the total number of vehicles emitting smoke in cities and coming second to taxi cab as pollutant-emitting vehicle in Nigerian cities

5.1 Smoke Emission by Types of Vehicle

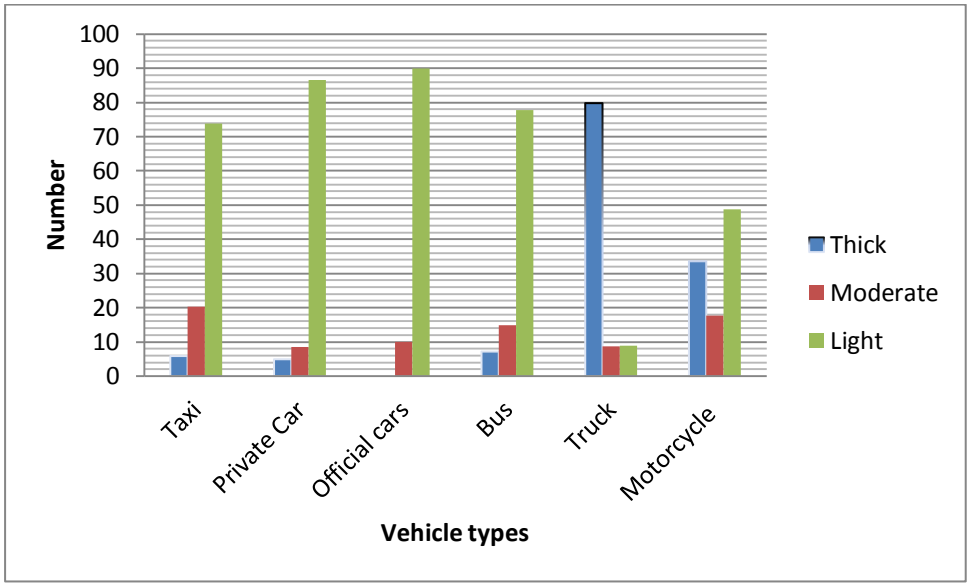
Thickness of smoke emission by types of vehicle is more informative and meaningful than ordinary numbers of vehicle featuring in the traffic composition. This is shown in Table 4. However the real meaning of distribution is presented in the percentage of distribution as shown on the same table. The figures to be compared are converted to percentages as a form of minimal standardization. In the table, the thickness of smoke emitted by different types of vehicle is demonstrated as judged by the differential scale indicated to the left. For example, in general terms, private cars emit least smoke with 26% of very light smoke while trucks emit greatest amount of smoke with 57.17% very thick smoke. The rate of emission is shown on a bar scale chart in Fig.1.

Table 4: Composition of Traffic and Rate of Smoke Emitted

	Taxi cab		Private car		Official vehicle		Bus		Truck		Motorcycle		Others	
	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Very light 1	5.12	77	13.43	162	26.00	13	5.49	34	0.44	5	5.66	69	20.00	2
Light 2	68.66	1022	73.13	882	64.00	32	72.37	448	10.93	134	43.11	526	30.00	3
Moderate 3	20.31	302	8.54	103	10.00	5	14.86	92	8.72	106	17.62	215	30.00	3
Thick 4	3.07	46	1.58	19			2.91	18	22.73	278	11.80	144	10.00	1
Very thick 5	2.84	42	3.32	40			4.36	27	57.18	698	21.80	266	10.00	1

Source: Author's Fieldwork, 2005

Fig. 1: Bar chart of Smoke Emission by Vehicle Types



Taxi cabs emit mostly light and moderate smoke. Private cars emit mostly light smoke. Here, it must be pointed out that in large cities such as Ibadan, where traffic is dominated by intra city bus service, the picture is different with the very thick smoke emitted by badly maintained buses.

It is clear from our finding that most trucks are of diesel engine which is notorious for smoke emission. Similarly, motor cycle is also the greatest emitter of smoke in cities. Two stroke engine automobiles which the motorcycle represents is also noted for smoke and gaseous emission.

5.2 Smoke Emission and Road Gradient

The cordon point or screen lines at which the traffic count and observations took place were carefully selected to give some gentle but reasonable slope from where the mark of vehicles ascending or descending the hills could be noted. The design paid off in the finding shown as in Table 5. In the table 2, it is shown that vehicles give thicker smoke while ascending hill than when descending. This is however not observable in other lower scale of measurement. The rate of change of emission in slope-related between however, varies among vehicle types.

Table 5: Smoke emission according to road gradient

	Vehicle descending		**Vehicle ascending**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Very light	192	6.82	186	6.20	362	6.50
Light	1639	58.20	1856	61.91	3047	60.10
Moderate	302	10.71	353	11.76	826	11.25
Thick	196	6.96	217	7.24	506	7.10
Very thick	487	17.31	387	12.90	1074	15.05

Source: Author's field work, 2005

The finding here implies that people and buildings located on the hill slope require greater protection and care from smoke as air pollutant.

5.3. Time of the Day and Vehicle Pollutant Emission.

Further investigation was carried out as to the temporal dimension of the study to find out the emission by the time of the day on hourly basis. By visual inspection of the data in Table 6 and Fig 2, it is not clearly evident if the smoke emission is time dependent.

Table 6: Analysis of Automobile Smoke Emission by Hourly Time of the Day

	7-8 am	8-9am	9-10am	10-11am	11am-12m	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm
Very light	49	23	27	25	17	50	40	31	17	52	31
Light	234	239	249	263	384	468	302	239	166	205	298
Moderate	165	129	71	57	108	60	65	49	36	30	42
Thick	88	62	43	31	46	65	55	30	32	27	33
Very thick	97	67	113	86	75	116	157	87	93	82	100
	633	521	504	463	630	776	619	432	342	396	504

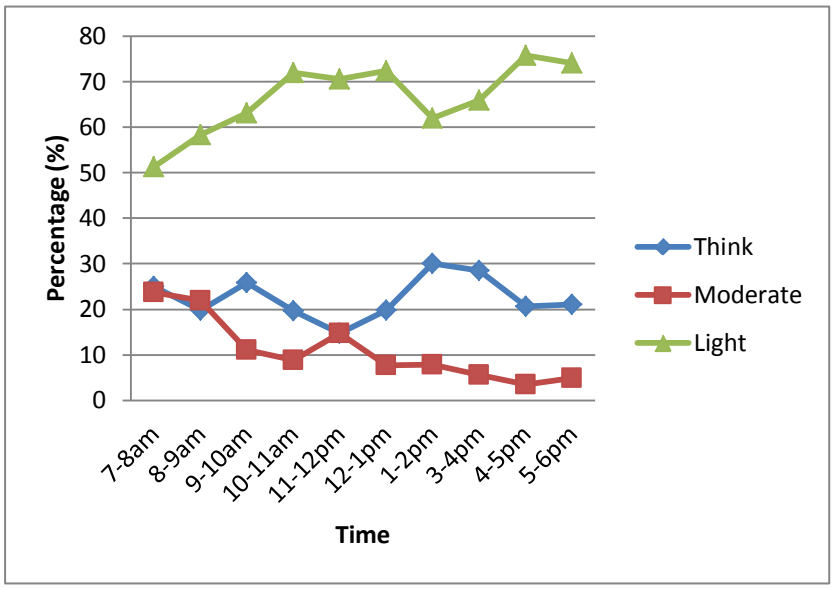
Source: Author's field work, 2005

Table 7: Converted to Percentages for Standardization

	7-8 am	8-9am	9-10am	10-11am	11am-12m	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm
Very light	8.06	4.61	5.57	6.10	2.86	6.70	6.79	7.41	5.29	13.64	6.55
Light	43.29	53.55	57.46	65.80	67.62	65.72	55.25	64.58	60.59	62.12	67.46
Moderate	23.70	22.07	11.13	8.87	14.76	7.23	7.92	7.64	5.59	3.54	4.96
Thick	12.48	6.53	6.76	4.76	5.87	7.22	7.59	4.40	6.47	4.55	4.76
Very thick	12.48	9.23	19.09	14.94	8.89	12.63	22.46	15.97	22.06	16.16	16.27

Source: Author's field work, 2005

Fig.2: Smoke Emission by Time of the Day



Source: Author's field work, 2005

It is shown that thickness of smoke varies with time of the day as well as vehicle types. For example, data reveal high emission of very thick smoke at 9 – 10 am (i.e. 19.09%), 1 - 2 pm (22.46%) and 3 - 4 pm (22.06%). While it is indicated that light smoke accounts for over 50% of the smoke emission between 7 am and 6 pm, yet, very thick smoke ranks second in the aggregate volume accounting for 20% in some hour period. It may mean that vehicles emitting very thick smoke such as trucks and motorcycles are prevalent on the roads at hours of _ to _ (state the hrs) noted for this. Conversely, private cars and official vehicles noted for light smoke are recorded on the roads at the time dominant light smoke is observed and recorded. Roughly, the hourly occurrence of smoke is complex, yet generally, thick smoke is emitted in the morning and the smoke becomes lighter as the day time grows.

6. Policy Implications and Recommendations

This study shows that more than half of the automobiles operating in the cities investigated emit visible smoke. This causes visual obstruction which bears heavily on safety, health and aesthetics. Smoky cloud cover in cities resulting from automobile emission and coming from other sources can cause smog and also pose danger to air traffic. Besides, smoke, emitted by automobiles, causes visual obstruction on roads. This could lead to road accidents. Smoke distorts and degrades the aesthetic value of cities. For instance, where there is heavy emission of smoke, properties such as buildings, road furniture and others are stained. Trees and flowers are also tinted with smoke dirt. Also, smoke is dangerous to human health. It increases and complicates cases of respiratory diseases such as asthma.

Hence, this calls for the catalytic control of automobile exhaust gases. It also requires some legal and monitoring control of emission of automobile smoke through action of vehicle inspecting officers. It also calls for long term and more technological reforms that would modify automobile engines to reduce combustion temperature. Health measures capable of purifying urban air or diffusing concentrated effluents could be embarked upon. Traffic management measures capable of directing automobiles away from urban zones of population concentration or a sort of pedestrian high risk area could also be executed.

As revealed in the study, vehicles giving great emission could be target of special control measure or policy formulation. For instance, trucks passing through the city should be

diverted away to by-passes or ring roads. When such by-passes are constructed, it should be realized that they are not to ease congestion only but also to serve the purpose of environmental sanitation. New development along such areas should specially be planned to create green belt between development lay-outs and the ring roads.

Similarly, the predominance of motor cycles in the traffic of Nigerian cities as a relatively new development requires serious control. The same can be said of common use of trucks for freight as against the trendy use of rail. The types operated and their maintenance need to be examined by government traffic division for environment-friendly systems as a form of quality control.

As an exploratory study, the findings are food for thought for the public, the governmental departments and agencies dealing with environment, transport, town planning, mechanical engineering and other related fields. It is also a stimulant for further studies (in all relevant field of studies) for researchers and policy makers. The current advocation for adoption of bicycling and walking as well as the use of mass transit in order to reduce automobiles on the city roads should be intensified.

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