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Strategies for Controlling Environmental Pollution caused by Internal Combustion Engine (ICE) in Auchi

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ABSTRACT

It is estimated that internal combustion engines in developing countries contribute about 4% of the global fossil carbon dioxide versus 18% by industrialized countries. The cost of urban air pollution is estimated to be 2% of GDP in developed countries and more than 5% in developing countries. Most of the vehicles used in Nigeria are imported when it is quite old with worn out engines and low energy efficiencies. As a result, such vehicles profusely emit exhaust gases which may be harmful to both human health and the environment. Controlling pollution from internal combustion engine (ICE) is vital to improving the quality of air and protecting public health. This study involves the control of environmental pollution from ICE, the impact of increasing penetration of city buses, introduction of tail pipe emission standards and hybrid cars and improvement of vehicle fuel economy are the major sources of air pollution. It was found that if left unabated, the emissions will continue to grow with the increasing number of motor vehicles. Establishment of an integrated transport system and improvement in power supply to avoid the use of individual ICE electricity generator should be done.

KEYWORDS: Environmental pollution, Internal combustion engine, Strategies, Control measures, Pollution, Air Pollution

1.0 INTRODUCTION

The degree of carbon dioxide in the environment has expanded by over 30% because of human activities. The impacts of environmental change are getting increasingly articulated and they incorporate dry seasons, floods, heat waves and changes in the climate designs. Worldwide temperatures have expanded by practically 0.8°C in the course of recent years. With no worldwide activity, it is normal that temperatures will increment further by 1.8 – 4 °C by 2100. It is foreseen that this ascent will bring about ocean level augmentation of 15 to 95 centimeters. While the transportation segment is vital to a country's economy and individual portability, it is likewise a critical wellspring of GHGs. About half of worldwide CO, HCs, and NOx outflows from petroleum derivative ignition originate from inside burning motors (ICE). The commitment of the vehicle part to add up to CO2 discharges in created countries is conjecture to increment from 20% in 1997 to 30% in 2020 (Ken *et al.,* 2004). The vehicle part represents practically all the oil request development around the globe (Ming *et al.,* 2008). The world transportation oil request has persistently ascended with expanding GDP. World conjectures show that transport oil request in creating countries will build multiple times more than in created countries. Expanding pay will cause

a gigantic increment in vehicle possession in creating nations, where the vehicle stock is relied upon to significantly increase. Creating nations represent about 10% of the worldwide car populace and somewhat over 20% of the worldwide vehicle vitality utilization. In examination, the United States alone expends about 35% of the World's vehicle vitality (Shiva, 2006).

Vehicles are among the principle buyers of world energy and they rule worldwide oil usage, expending up to 80% of transport vitality. The transport sector's share of oil consumption has been increasing steadily at around 0.6% per year. Current policies are not sufficient to control road vehicle energy use.. In creating countries, it is imagined that with rising salary and the quickly rising portability that goes with it, the expansion in car discharges will be much more prominent than the created countries. Consistent development in vehicular populaces has placed natural weight on urban focuses in different structures especially causing poor air quality. There is developing proof that joins vehicle poisons to human sick wellbeing. Engine vehicles are significant outflow hotspots for a few air poisons, including nitrogen oxides (NOx), carbon monoxide (CO), particulate issue (PM), and hydrocarbons (HCs) (WHO, 2005). These poisons have huge unfriendly consequences for individuals and the earth. Vehicle emanations cause both short and long haul issues related with wellbeing impacts. For instance, HCs and NOx are the forerunners of ozone gas, which has impacts extending from transient outcomes, for example, chest torment, diminished lung work, and expanded defenselessness to respiratory disease, to conceivable long haul results, for example, untimely lung maturing and incessant respiratory sicknesses (WHO, 2005). An away from of the approaching threats of expanded vehicle numbers broadcasting in real time quality should be set up.

The internal combustion engine has an important role to play in the effort to avert the dangerous effects of climate change because it heavily depends on fossil fuels. Currently, most emissions are concentrated in urban areas which account for the largest share of on-road transport energy consumption. An estimated one billion people in Africa are exposed to outdoor air emissions which exceeds maximum recommended levels world-wide (WHO, 2005). Many city premises operate generators as a backup to the insufficient electricity. With the increasing urban population and a creation of a large class of blue collar workers, there is an increasing demand for second hand vehicles in Nigeria necessitating increased air pollution around. Most of the vehicles used in Nigeria have very low energy efficiencies, mainly because they are imported into the country when quite old. The main considerations during importation are fiscal and not environmental. Nigeria being a developing country is very prone to the adverse effects of climate change because of its low capacity to adopt, lack of technology and institutional and financial capacities. Controlling pollution from the internal combustion engines is vital to improving the quality of the air and protecting public health.

The operation of ICEs comes with significant undesirable side effects, particularly in terms of air pollution in urban areas and emissions of greenhouse gases, which can impact global climate change. Evidence is also growing of ICE's negative impact on local populations, particularly on the poor in developing world cities (Meena, 2003). The health consequences of urban air pollution are high. Transport related air pollution increases the risk of death particularly from cardiopulmonary causes, allergic illness such as asthma, cancer, etc. The long term air pollution from cars in Austria, France and Switzerland triggered an extra 21,000 premature deaths per year from respiratory or heart diseases, more than the total number of annual traffic deaths in the three countries (WHO, 2005).

The study will be a starting point for the sensitization of the public and policy makers about the imminent dangers of air pollution in Nigeria using the key findings. Results from this study will be used by researchers, the public, city planners and local authorities to understand transport energy

usage and emissions levels in the city. The objective of this paper is to evaluate the strategies to control pollution from internal combustion engine.

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. Air pollutants are classified in two main categories as either primary or secondary. Primary pollutants are emitted directly into the atmosphere by a stationary or mobile source. Secondary pollutants are formed in the atmosphere as a result of physical and chemical processes such as oxidation. The primary pollutants include CO, HC, VOCs, SOx, NOx, PM and compounds of lead. Secondary pollutants include nitrogen dioxide, photochemical oxidants e.g. Ozone, etc. The main sources of air pollutants are either natural or anthropogenic. Natural sources include forest fires, volcanoes, vegetative matter, etc. The anthropogenic sources include industrial processes, power generation, commercial and domestic fuel use, solid waste disposal, transport, etc. Automobiles are by far the predominant contributor to air pollution among the mobile sources.

Most vehicle emissions are a product of the engine combustion process. Most passenger cars and light-duty trucks use a gasoline fueled four-stroke, spark-ignited (SI) internal combustion engine. The main pollutants of concern in the case of SI engines are NOX, CO, HC, and organic toxics (i.e. benzene, acetaldehyde, formaldehyde, and 1,3-butadiene). Particulate Matter (PM), a very important pollutant in the case of compression-ignition engines, is produced in very small amounts in SI engines (Degobert, 1995).NOx and CO are formed during the combustion process and are emitted only from the tailpipe. Hydrocarbons and air toxics may originate both from the tailpipe in the form of unburned or partially burned fuel, as well as in the form of evaporative emissions from the fuel tank, fuel lines, and losses during the refueling process. Evaporative losses of HC are estimated to be about the same order of magnitude as the contribution from the exhaust.

2.0 IMPACT OF DIFFERENT EMISSION TYPES

In spite of the fact that autos add to the debasement of air quality, there is no straightforward methods for estimating the exact effect. The effect will shift from city to city, contingent on such factors as vehicle thickness, the split among petroleum and diesel vehicles, the kind of vehicles out and about and their normal age, the traffic the board frameworks set up and air conditions. The contaminations from engine vehicles have noteworthy unfriendly consequences for people and the earth. Vehicle emanations cause close term issues related with wellbeing impacts. For instance, hydrocarbons and nitrogen oxides are the antecedents of ozone, which have impacts running from momentary results, for example, chest torment, diminished lung work, and expanded vulnerability to respiratory disease, to conceivable long haul outcomes, for example, untimely lung maturing and constant respiratory sicknesses.

i. **Carbon Monoxide:** Carbon monoxide (CO) is a tasteless, odorless, and colorless gas produced by the incomplete combustion of carbon-based fuels. Exposure to carbon monoxide interferes with absorption of oxygen from haemoglobin in the red blood cells (Ming *et al.,* 2008). After a prolonged exposure, this impairs perception and thinking, slows reflexes, causes drowsiness and can cause unconsciousness and death. A combined exposure to CO and other pollutants, promotes morbidity in people with circulatory problems. It is associated with less worker productivity and general discomfort.

ii. **NOx:** NOx is a generic term for mono-nitrogen oxides namely NO and NO_2 which are produced during combustion at high temperatures. At ambient temperatures, oxygen and nitrogen do not react with each other. However, in an internal combustion engine, high temperatures lead to

reaction between N2 and O2 to yield nitrogen oxides. NOx is categorized into three types that include; thermal NOx, fuel NOx and Prompt NOx (Bosch and Jansenn 1988).

iii. **Poly Aromatic Hydrocarbons (PAHs):** PAHs are a group of organic chemical compounds that contain two or more aromatic benzene rings fused together. More than 500 PAHs have been detected in the air: the lighter PAHs are found in the gas phase, while PAHs with five or more rings, such as benzopyrene, are usually adsorbed onto fine PM. In the past, the major urban source of PAHs in Europe was the domestic burning of coal. Today, vehicle emissions are the dominant source in most urban areas, though wood combustion may be important in some areas, such as Scandinavia and Eastern Europe. In general, roadside PAH concentrations are higher than urban background concentrations, which in turn are higher than rural concentrations. Some PAHs are carcinogenic, and benzopyrene is often used as a marker of the carcinogenic potency of ambient total PAHs. The particulate fraction of PAHs is usually of greatest concern, since it contains the majority of the carcinogenic compounds and can be transported over long distances. Though routine measurement of PAHs has been scarce in the past, PAH concentrations appear to be an order of magnitude lower in urban areas today than they were when coal burning was commonplace (Ming *et al.,* 2008).

iv. **Particulate Matter (PM):** PM in ambient air comes partly from natural sources, such as wind-borne soil, sea spray and emissions of biogenic, organic compounds. Anthropogenic sources include not only fossil-fuel combustion, but also mining, agriculture and industry. PM emissions from road traffic come from exhaust pipes, tyre wear, brake linings and resuspension of road dust.PM is emitted directly (primary emissions) or formed in the atmosphere by conversion of gaseous precursors that is, nitrogen oxides, sulfur dioxide, VOCs and ammonia into secondary particles. PM may be transported in the atmosphere over hundreds to thousands of kilometers, depending on the particle size.

v. **Health Effects - Case Studies:** Vehicle emissions contribute to adverse health effects in humans; in addition these emissions are harmful to terrestrial and aquatic ecosystems, and contribute to crop damage and other welfare losses. However, most of the studies conducted have analysed the effects of the pollution mix generated by a variety of sources, which include traffic, communal and industrial combustion, and long-range transport of air pollution. Identifying the effects related specifically to the pollution created by transport is a challenge.

3.0 MATERIALS AND METHOD

3.1 Study Area

This study will be carried out in Auchi metropolis, Auchi is located between latitude 7^0 10' and 7^0 20' north of the equator and longitude 6^0 16' and 6^0 36' east of the Greenwich Meridian with an altitude of 207m. Auchi is a fast growing cosmopolitan city which is also a route between major cities like Abuja, Okene and Benin. There are a lot of vehicular activities within the city which makes it susceptible to air pollution from ICE.

3.2 Method of Investigation

The vehicle parc numbers were obtained from the Auchi Road safety office. An interview which was aimed at determining the age of vehicles, mileage and peoples' perceptions on the impact of vehicle emissions was prepared and administered to 50 automobile operators. The interviewee sample size was selected based on the availability and co-operation of automobile operators to respond to the study. The study focused on minibuses, personal vehicles and motor bikes which

comprise about 80% of the vehicle parc. The Vehicles were randomly selected based on the age, type and model.

3.3 Equipment Set up and Measurement

A gas analyser was used for the experimental work. The instrument weighed 1kg and could run for up to 4 hours on its internal re-chargeable battery. The gas analyser comprises of a 6-gas analyzer meter, an exhaust probe and a printer as shown in the Figure2-2. The meter is fitted with water, a filter and a protective rubber sleeve. The equipment measures the volume percentage of CO, CO2, O2, NO, HC and NOx in the exhaust gas. The CO, CO2, O2, NO and NOx emissions are measured in %s whereas HC is measured in ppm. The equipment records the oil temperature and the fuel/air ratio (Lambda). The instrument can be used for testing petrol, diesel, Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) exhaust gases.

At the start of each experiment, the gas analyser was first purged and then a leak test carried out to ensure there was no air trapped that could affect the results. The filter was regularly checked to ensure that it was clean and not clogged with particles. When clogged, the gas analyser does not pass the leak test. The startup time before testing was about three minutes. When ready for use, the analyser probe was fitted in to the exhaust pipe and clamped to keep it firmly held. The vehicle operator was required to run the engine in idle mode for five minutes and then measurements were done. The typical time for testing one vehicle was five minutes. In the case of motorcycles, the operators were required to ride the motorbike through a distance of 1 km distance and then measurement of the emissions was done.

3.4 Data Analysis

The emission data for CO and CO2 was retrieved from the gas analyser in percentages. The data for HC, NOx and NO was in ppm. The data retrieved was entered into an MS Excel sheet for further processing. The data was standardized by converting it from % and ppm to mg/m^3 using the formula below.

$$1\,ppm = \frac{M}{22.4} \qquad ---Eq.1$$

Where:
22.4 (in liters) is the molar volume at Standard Temperature and Pressure (STP)
M is the molecular mass

Quality assurance was done for the collected data. The main aim was to create a database that contained valid data. The data was analysed to identify any errors that existed. Such errors were corrected where possible or invalid data eliminated if they could not be corrected. Where measurements were taken inaccurately, the experiment was repeated and better values taken or in other cases an average value derived.

4.0 RESULTS AND DISCUSSION

4.1 Vehicle Age and Mileage

The field survey and interview revealed that most of the personal vehicles and mini buses for public transport are imported into the county as second hand overhauled vehicles. Out of the 50 vehicle owners interviewed, 37 indicated they had purchased their vehicles from bonded warehouses and from other existing owners. 90% of the vehicles lie between 8–15 years indicating that the Nigerian vehicle parc is quite old. The vehicle owners indicated that at purchase time, some of the

vehicle mileages were altered to reflect lower mileage indicating that there is a high level of uncertainty in the recorded vehicle mileage data. The vehicle mileage for minibuses ranged between 40,898 km and 390,965km with an average of 20,404 km and standard deviation of 92,705km.

The vehicle mileage for the personal vehicles ranged between 5,668 km and 212, 017 km with an average of 108,349 km and standard deviation of 63,307.56km. The results show that on average minibuses cover longer distances compared to personal vehicles. This is because minibuses are used within the city centre for public transportation necessitating them to drive more compared to personal vehicles.

4.2 Automobile Emissions

The analysis of the emissions from different vehicles showed that CO2, NOx, CO, HC and NO are released during combustion of fossil fuels. The results obtained are a combination of all the vehicle types considered in the analysis. They cover vehicles with different engine types and sizes. This because of the difficulty involved in accessing vehicles for the experiments. The analysis was done on tail pipe emissions.

4.3 Carbon Dioxide Emissions

The general trend in emission levels shows that minibuses emit more CO2 compared to both the personal vehicles and motor bikes. The motor bikes emit more CO2 compared to the personal vehicles. This is supported by the findings from the survey where car owners were asked how often they carried out maintenance work on their vehicles. Majority of the minibus operators showed reluctance in having a regular maintenance schedule with some doing it after 3–4 weeks. However, the survey showed that vehicles owned by individuals or organizations were well maintained with a weekly maintenance schedule. The mini bus operators viewed the maintenance program as costly and hence the reluctance to have vehicles regularly maintained. Poor maintenance results in poor engine performance.

4.4 NOxEmissions

The highest level of NOx observed was from the motor bikes and minibuses at 0.15 mg/m3 and 0.13 mgm3. The personal vehicles emmitted less NOx compared to the minibuses and motor bikes with the highest amounts at 0.06 mg/m3.The amounts of NOx emitted is less in amount compared to the CO2 released for all the automobile types. NOx is produced during combustion at high temperatures. At ambient temperatures, oxygen and nitrogen do not react with each other. However, in internal combustion engine, high temperatures lead to reactions between nitrogen and oxygen to yieled nitrogen oxides.

4.5 HC Emissions

The level of HC emissions observed is highest in the motor bikes at 2.59 mg/m3 followed by minibuses at 0.72 mg/m3 and personal vehicles at 0.2 mg/m3. However, the high amounts observed in the motor bikes correspond to those with the highest mileage and very old. During the study the very old motor bikes were also found to belong to the two stroke motor cycle category which emits significant amounts of HC compared to the four stroke type. HCs result from incomplete combustion in the engine due to reduction in the level of oxygen and may represent the number of particles being emitted. The low emission levels in the personal vehicles are atrributed to the high maintenance standards and less travel as observed during the study.

4.6 NO Emissions

The amount of NO emitted is low compared to the NOx and CO levels. The highest observed amounts were 0.19 mg/m3, 0.15 mg/m3 and 0.06 mg/m3 for minibuses, motorbikes and personal vehicles. In all automobile types, there were some that never emitted any NO. This may be attributed to the fact that most of the NO reacts to form NOx.

4.7 CO Emissions

Emission of carbon monoxide is an indicator of incomplete combustion in the engine. The minibuses emitted more carbon monoxide than the personal vehicles and motor bikes. The emission amounts were 110 mg/m^3 for the minibuses, 83 mg/m^3 for the motor bikes and 16.9 mg/m^3 for the personal vehicles.

5.0 CONCLUSIONS

The findings indicate the level of pollution is usually high in many cities and will continue to grow if left unabated. The potential diseases caused by this emission include lung cancer, bronchitis, cardio vascular diseases and neurobehavioral effects.

The reduction in ICE emissions can be achieved in two main ways that include reduced consumption of fossil fuels and increased efficiency in transport energy use. Several mitigation methods can be applied to cause a reduction in the emission level. They include;

- Better land use planning to include expansive roads to avoid congestion
- Car pooling to allow more occupants per vehicle
- Designing an integrated transport system with big buses and trains,
- Encouraging alternative modes of transport such as walking and cycling,
- Introduction of more efficient automobiles with improved fuel economy.
- Traffic management
- Use of alternative fuels such as biofuels

6.0 RECOMMENDATIONS

Several mitigation methods that can be considered for implementation at policy level to ensure a sustainable environment. Some mitigation methods are easier to implement compared to others. The key recommendations below cover practical and easy to implement mitigation methods. If emission reduction is to be achieved in Nigerian cities, it is recommended that a comprehensive motor vehicle pollution control program be designed to implement the proposed NEMA vehicle emission standards. This program will assist in the implementation of the set vehicle emission standards through an inspection and monitoring program.

The following control measures and strategies are hereby recommended from the study:

Theatmosphere has several built-in self-cleaning processes such as dispersion, gravitational settling, flocculation, absorption, rain-washout, etc to cleanse the atmosphere. However, control of contaminants at their source level is a desirable and effective method through preventive or control technologies.

Some of the measures to reduce and control air pollution are as follows:

i. Air pollution can be checked only through the combined efforts of the government, non-government organizations and the general public.
ii. Automobile engines should be redesigned in such a way that their emissions cause minimum pollution. Old automobile engines should be replaced by new ones. People should be encouraged to share the vehicle, and to avoid vehicles for short distances.
iii. Cheap devices for controlling air pollution should be developed.
iv. Forest fires should be checked. Adequate preventive measures should be adopted to protect the forests.
v. Green belts should be created. Such areas should be developed around densely populated cities. There should be strict restriction for establishment of large buildings and industries along the Green belt areas.
vi. In industries there should be arrangement for pollution control.
vii. Industrial areas should be located at a safe distance from the residential areas.
viii. Newly designed smoke free furnaces should be used.
ix. The forest cover should be protected. Adequate forest cover is essential for maintaining the quality of air. Trees absorb carbon-dioxide (CO2) and releases oxygen (O2).
x. Use of railway steam engine should be stopped. The burning of combustible materials such as coal produces poisonous gases that are released into the air. Electric engines should be used instead of steam or diesel engines.

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