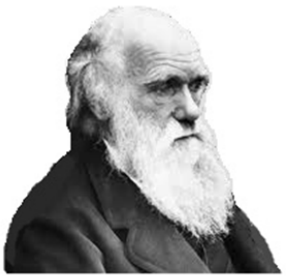
Available online at www.worldnewsnaturalsciences.com



World News of Natural Sciences

An International Scientific Journal

WNOFNS 40 (2022) 49-64 EISSN 2543-5426

A review on the effects of fumes from tricycles (keke) on health and environment, Nigeria

Ruth Oghenerukevwe Eyankware Ulakpa[1,*], **Wisdom Chukwuemeke Ulakpa**[2]

[1]Department of Environmental Management and Pollution Control, Nigeria Maritime University, Okerenkoko, Nigeria

[2]Department of Chemical Engineering, Federal University of Technology Minna, Niger State, Nigeria

*E-mail address: rutheyankware@yahoo.com

ABSTRACT

A literature analysis was conducted to assess the effects of tricycles and health information in the Nigerian environment, with the goal of studying their impact on human health and the environment. According to the reviewed literature, road users are constantly exposed to tricycle emissions and other environmental pollutants, which may be hazardous to health and cause climate change due to air pollution consequences, as described by a few academics. CO, N_2O, SO_2, CH_4, H_2S, PM, S_2O, Pb, and VOCs were found to be above NAAQS and FMEnv, indicating that the ambient air around Nigerian towns and cities was polluted. The accumulation of pollutants in the air, on people (road users), and in the immediate environment creates major health and environmental dangers. If not carefully monitored, the occurrence of these contaminants in humans and the environment may tend to increase in the coming years, having a harmful influence on man and the ecosystem as a whole. As severe as it gets human and climatic changes have unavoidable health consequences. As a result, regular re-evaluation of tricycle emissions and their influence on human health and the environment is essential.

***Keywords*:** Tricycles, Effects of fumes, Environment, Human health Pollutants, Nigeria

1. INTRODUCTION

Rising income levels in many emerging nations have resulted in some changes in household living patterns [1], and these lifestyle changes have an impact on energy demand in various sectors of the economy [2]. One such area is transportation. Transportation is an

(Received 24 October 2021; Accepted 13 November 2021; Date of Publication 14 November 2021)

important aspect of human activity that supports socioeconomic activities on both the micro and macro levels. Transport that is efficient, the system promotes access to important economic inputs including resources, information, and technology, while also lowering obstacles to free movement of commodities and people [3].

Road transportation, which is the primary means of transportation in many developing countries, has seen increased activity as the number of personal vehicles or tricycles per capita has increased. This is because as household income rises, so does the desire for better mobility, and households tend to shift from non-motorized to motorized modesmobility in any form of transportation. Other factors that have contributed to the rise in personaltricycle or vehicle ownership and use for mobility include socioeconomic factors (population age distribution, household composition, employment, and educational level); the state of supply and efficiency of public transportation services; the availability of high-quality road infrastructure; and government policies (e.g. tax, insurance) toward automobiles [4]. The number of people who own and utilize tricycles is increasing in developing nations. As a result, energy demand, particularly for refined petroleum products, rises. The transportation sector remains one of the core sectors of end-use of modern energy and, by extension, greenhouse gas (GHG) emissions globally [5]. This is due to the captive position of the road transport sector with regard to the use of refined petroleum products as fuel.

As a result of these consequences, the need to minimize carbon emissions has become a universal concern. This is due to the fact that its negative consequences are felt all around the world [6]. The ongoing growth of urban populations has increased their significance as a source of pollution. Only Lagos in Nigeria, Delhi in India, Jakarta in Indonesia, and Mumbai (Bombay) in India saw higher than 2.4 percent urban population growth between 1975 and 2005 [7]. Lagos is the commercial capital of Nigeria. After Cairo, it is the world's second most populous and fastest growing city [8]. The most significant source of anthropogenic emission is assumed to be road transport, as it is in the majority of cities. Commercial transportation is an important part of economic growth in emerging countries like Nigeria.

In developing countries such as Nigeria, buses, taxis, motorbikes, and tricycles are the most popular modes of commercial transportation [9]. The chore of tri-cycling is riding a three-wheeled vehicle (tricycle), commonly known as a keke, (in Nigeria) three-wheeler, tuk-tuk, trishaw, autorick or bajaj (in Indonesia), and auto rickshaw (in India).Tri-cycling has recently gained popularity as a commercial mode of transportation in a number of developing nations, particularly in Asia and Africa. There are various types and styles of tricycles. A sheet-metal body or open frame resting on three wheels, a canvas roof with drop-down side curtains, a small driver's cabin with handlebar controls, and a car-go, passenger, or dual-purpose vehicle are the most popular types. At the bar, there is a designated area. The small size and narrow configuration of tricycles are ideal for navigating Nigerian roads, which are notoriously congested. However, due to the configuration of tricycles and the environmental exposure of tricyclists to airborne pollutants, commercial tri-cycling may pose some health risks [10].

The absence of doors and windows on tricycles exposes the occupants to uncontrolled environmental pollution during transportation [11]. Tricycles, on the other hand, are a great way to get around, are generally driven by fuel and, as a result, pollute the environment significantly. At least carbon dioxide and water are produced during the complete combustion of fuel [12]. In most cars and tricycles, however, combustion is incomplete, resulting in the creation of a variety of gaseous, liquid, and solid chemicals such as nitrogen oxide (NO_2), carbon monoxide (CO), ozone, and sulfur dioxide (SO_2) [13].

Diesel exhaust particulate (DEP) contributes significantly to particulate matter (PM) in the air [14, 15]. Furthermore, many of the tricycles on the road are old and poorly maintained, and in developing countries like Nigeria, transportation regulations are either non-existent or ineffective. According to studies [16-18], such a scenario results in high levels of traffic congestion as well as traffic-related ambient air pollutants, which have been shown to account for up to 90–95 percent of ambient CO, 80–90 percent of NO_2, SO_2, hydrocarbons, and particulate matter in other developing countries in Sub-Saharan Africa and other parts of the world. The ambient air quality in various Nigerian cities appears to have deteriorated as a result of exposure to such environmental toxins [19-22].

Commercial drivers, including tricyclists, are more likely to be exposed to exhaust particulates and other particulate matters in the air because they spend extended periods on the road [23, 24]. Long-term exposure to exhaust has been linked to respiratory and cardiovascular problems. Affected people's pulmonary functions may be altered as a result of such respiratory impairments. In light of the foregoing, tri-cyclists whose occupation entails spending the majority of their daily work on road are more likely to develop respiratory problems as a result of their work. [25] Found that tri-cyclists in India have pulmonary problems. However, despite their high rate of exposure, the health effects of occupational exposure to petroleum vapoursand air pollution from tricycle sources are mostly unknown among Nigerian tri-cyclists [26]. Given the prevalence of tricycles in the road transportation industry and the congested character of most Nigerian cities, it is necessary to assess the negative consequences.

In the Nigerian environment, the impact of exhaled gases from commercial tri-cyclists will provide the evidence needed to enforce regulations aimed at preventing and reducing occupational and health risk exposures. As a result, the purpose of this study was to evaluate the effects of tricycle-emitted fumes on human health and environment. This study is likely to help warn people about the dangers of gases generated by tricycles to people and their surroundings in the future.

1. 1. Tricycles are a Major Source of Pollution

A number of factors can be identified as impacting the amount of emissions attributed to tricycle fumes, and an effective plan must account for all of them. They are as follows:

i. An overabundance of tricycles in the overall examination of fume emissions,

   The level of activity or tricycle use is a crucial component to consider, especially when long-term solutions are envisioned to help avoid the emergence of a problem. Various studies in Nigeria have found that increases in tricycle activity have either significantly increased the amount of CO_2 emitted in the sector or significantly dampened the reduction in CO_2 emissions that would have occurred, the latter due to efficiency improvements in the last three decades of the twentieth century. In the absence of a policy to address trike use, the global market for tricycles is expected to rise at a rate of 2.5 to 4% per year between 2010 and 2030.

ii. Technology and the age of the fleet used

   Because performance deteriorates with age, older tricycles are linked to higher emissions of both global and local pollution.

iii. Inadequate tri-cycle upkeep

Deterioration of emission characteristics is linked to trike owners' maintenance habits, notably for local contaminants produced through exhaust. Misfueling tricycles (keke) with leaded fuel, even once or twice, can do major harm to the vehicle's capacity to function properly, as well as degrade it over time due to other natural impurities in fuels. Emissions from neglecting exhaust after-treatment maintenance are likely to rise if there is no effective strategy in place to ensure that these systems are effectively maintained.

iv. iv. Fuel scarcity or improper use

For several reasons, fuel is a consideration. Regulatory agencies may incorrectly define fuel types for the conditions in a given area, resulting in unnecessary pollution emissions from tricycles. Owners of tricycles may over-fuel due to ignorance or a faulty pricing signal. Finally, dishonest retailers may adulterate or replace fuel, frequently as a result of a misguided price signal.

2. LOCATION AND ACCESSIBILITY

Nigeria is a West African country bordered on the west by the Republic of Benin, on the east by Cameroon and Chad, and on the north by Niger. Nigeria's coastline is bordered to the south by the Gulf of Guinea and to the northeast by Lake Chad. The country's area is 923,768 square kilometers (356,669 square miles) in size [15]. The most substantial topographical area is the Niger and Benue basins, with rocky highlands to the southwest [28] and [29]. It can also be found in the tropics, where the climate is humid and damp throughout the year. Affecting the country are the tropical monsoon, the Sahel, tropical savanna, and Alpine climates, which are just a few of the four types of climate. During dry seasons, temperatures can reach 44°C (111.2°F) in some regions, especially near the coast, and range from 16 °C to 25 °C in highland areas with temperate conditions along the Cameroon border [30]; [31]. The rainfall in southern Nigeria varies from 4000 mm (157.5 in) to 2000 mm (118.1 in) every year, with a total of 1100 mm (43.3 in) in central Nigeria. Nigeria's population is estimated to be around 202 million people, with a population density of 221 people per km^2 (571 people per m^2) and a median age of 17.9 years ([32]; [33])

Nigeria's population is growing at a faster rate than that of other similar-sized countries, at around 2.62 percent. However, by the year 2050, this rate of growth is expected to drop to 2.04%. Nigeria's GDP in 2018 was $444,92 million, up 1.9 percent from 2017 (International Monetary Fund, 2018 [34].

3. DISCUSSION

3. 1. Tricycle Effects on Humans (Road Users) and the Environment

The widespread use of tricycles in the Nigerian environment has resulted in a slew of environmental issues. As several publications and opinions have documented, human actions have affected the ecosystem. Pollution from tricycles is a severe threat to human life and the environment. After establishing in the paper's introduction that air pollution, global climate issues, noise, and water are among the key environmental media or methods via which transportation can affect the environment as shown in Figure 1a and b. Pollution, accidents, land use, and habitat fragmentation are all factors that contribute to habitat fragmentation [35].

Reviewing the extent of contamination and, if feasible, quantifying it, was deemed essential. Unlike decades before, when the means of transportation was barefoot, the majority of the activities are in some way tied to contemporary day tricycle manufacture. [36] Believe that the growth in population and economic activities in Port Harcourt has resulted in a deterioration of ambient air quality. PM 2.5 and PM 10 were found within Port Harcourt. According to the report the control were above NAAQS limit of 35.0 µg/m^3 and 150.0 µg/m3 respectively. Total suspended particulate matter (TSPM) was 208.0 µg/m^3, and 398.53 µg/m^3which was above NAAQS limit of 200.0 µg/m^3. The other measured parameter including hydrocarbons, CO, N_2O, S_2O were above NAAQS and FMEnv signifying that the ambient air around study areas were polluted. [37], pointed out that with in Kano metropolis CO_2 emission from transportation revealed that following emissions in metric tonnes per hour; shows 15.75 from cars and buses, 6.08 from tricycles and 0.56 from lorries. According to their research, the hourly emission of 22.39 tonnes was recorded. According to [38], the results for tricycles pollution in Illorin metropolis in Nigeria revealed that the concentration levels obtained for CO and SO_2 were 6.32 ppm and 0.126 ppm respectively. When compared to the FEPA standards, the SO_2 concentrations obtained from ambient sources was found to be substantially higher than the SO_2 (0.01–0.1 ppm) USEPA limit.

Figure 1(a,b). Showing traffic Congestion from tricycles in Delta State.

The CO level obtained from both (open and closed windows) was below the NESREA (10–20 ppm) and USEPA requirements (35 ppm). [39] Believed that tricycle emissions caused sleepiness, runny noses, heavy eyes, asthmatic attacks, and headaches by increasing acidity,

pH, and the amount of dissolved chemicals such as NO_3, SO_4, and CO_2. According to studies, the Nigerian environment releases a lot of CO_2 from tricycle operations [40]. They went on to say that it implies the presence of particulate matter and other dangerous fumes, despite the fact that their findings contradict a report from [41], which claimed that due to a lack of development in rural areas, there is high population migration to urban areas, resulting in more environmental-related problems such as; pollution and solid waste management posing a greater risk to the environment in Nigeria as shown in Table 1. [42] went on to show that there is a link between increased tricycle ownership, increased exposure to tricycle emissions, and an increase in environmental diseases as shown in Figure 2 and Table 1. Their findings suggest that tricycle emissions and human health are linked in the Jos plateau state resulting in (asthma, cardiovascular disease, and bronchitis). According to the findings, as the number of transportation system increases, so does the number of diseases and deaths caused by air pollution increase. [43].

Table 1. Waste produced by Tricycles

S/N	Tricycles' Major Components	Chemical constituent	References
1	Tires and tubes	Natural and synthetic rubber (styrene-butadiene rubber) are used in elastomers, oils, resins, carbon black, steel cord, and silica (SBR)	[58, 59]
2	Battery box, plates, and the connectors	Ni, Cd, Pb, HDPE	[60]
3	Components of the automotive exhaust system	Cr, Ni, Si, Fe, Mn	[61]
4	Bearings, bushings, and valves for engines	Fe, Cu, Sn, and Zn	[55]
5	Block of an engine	C, Si, Mn, Fe, Ni, Zn, Cu, Mg	[61]
6	Pumps and valve	Cu, Co, Be, Al	[58]
7	Tanks and radiator cores	Alloy of Cu, Zn, and steel	[58]
8	Cylinder of an engine	Cast iron and Al alloy	[61]
Fe stands for iron, Al for aluminum, Si for silicon, and Mg for magnesium. Copper is abbreviated as Cu, and zinc is abbreviated as Zn. Cobalt is the chemical symbol for cobalt. Be = beryllium, B = beryllium, B = beryllium, Ni is the chemical symbol for nickel. Mg = manganese, Sn = tin, Cr = chromium, Mg = manganese, Sn = tin, Cr = chromium, Mg = manganese, Steel is an alloy of iron and carbon, and HDPE stands for high-density polyethylene.			

According to statistics on tricycle registration, between 2010 and 2020, the number of registered tricycles increased from 38,000 to nearly 1.6 million as shown in Figure 2 below. They went on to say that the Nigerian government's Federal Road Safety Commission (FRSC) had registered over six million tricycles. On average, these have increased road transportation emissions in Nigeria. [44] Further stated that the amount of some specific air pollutants, such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and hydrogen sulfide (H_2S), which are primarily results from tricycles emission, has increased. In Abeokuta, hydrogen sulfide (H_2S), carbon monoxide (CO), and methane (CH_4) are all present. They also acknowledge that CO, SO_2, NO_2, H_2S, and CH_4 concentrations ranged between 73.72±0.92 and 82.89±3.38 mg/m^3; 0,046±0.005 and 0.067±0.017 mg/m^3; 0.217±0.02 and 0.399±0.02 mg/m^3; 0.167±0.017 and 0.265±0.011 mg/m^3; 0.171±0.024 and 0.442±0.385 mg/m^3.

Autosampler gasman (ATEX4 model). While traffic volume was responsible for 15.5, 49.5, 51.2, and 64.9 percent of CH_4, NO_2, SO_2, and CO concentrations in air samples taken along the designated roads. Several health concerns have been reported to health facilities as a result of these pollutants, including cough (56.4 percent) and breathing difficulties (23.6 percent), among others. [46], were of the opinion that the Hydrocarbon (HC), sulphur dioxide Concentration measurement (SO_2) are major pollutants in the city

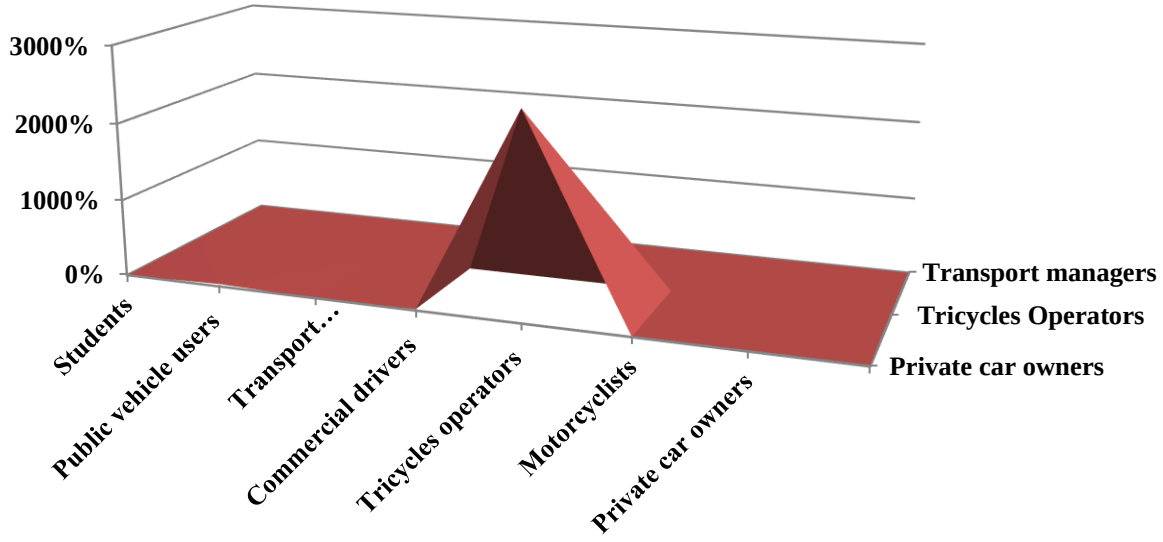


Figure 2. Shows that transportation sources account for a large percentage of Nigeria's emissions.

The effect of tricycle emissions of nitrogen dioxide (NO_2) and carbon monoxide (CO) was higher than the allowed threshold in Port Harcourt, Rivers State. According to [47] study in Owerri, South-east Nigeria, hydrocarbons, oxides of nitrogen, carbon monoxide, and carbon dioxide levels have increased dramatically as a result of increased tricycle emissions and the start of commercial operations. [48] Looked at the levels of gaseous emissions (CO, NO_2, and SO_2) at four different locations in Benue State's Makurdi metropolis. According to their findings of the study, CO has the highest concentration (0.57–10.2 ppm) in all of the sampled

locations, followed by NO_2 (0.01–0.11 ppm) and SO_2 (0.00-0.1 ppm). As a result, the study's findings revealed that emission levels in the city, particularly in the afternoon, were slightly higher than the Nigerian air quality standard's accepted safe limits of 10 ppm for atmospheric CO, 0.04-0.06 ppm for NO_2, and 0.1 ppm, respectively, for SO_2. If left unchecked, these have negative health consequences and may eventually lead to climate change as shown in Table 1 and 2 [49] agreed that atmospheric carbon dioxide (CO_2) emissions at road junctions in three major cities in Niger State, namely Minna, Bida, and Suleja, fall between an average, with CO_2 emission levels of 2,856.6ppm, 2,731.1 ppm and 2,518.1 ppm, respectively, when compared to the national average. It was 2,731.1 ppm and

Figure 3. Showing Air Pollution emitted from tricycle (keke) in Onitsha, Anambra State.

2,518.1 ppm, respectively, when compared to the national average. It was discovered to be approximately eight times higher than the internationally accepted safe limits of 350 ppm atmospheric CO_2, but less than the Occupational Safety and Health Administration (OSHA) permissible exposure limits of 5,000 ppm, which has negative health effects and may contribute to climate change in the long run if left unabated. According to [49], CO and CO_2 concentrations in Minna, Niger State were a little below the Federal Environment Protection Agency's

standard. Despite the fact that various studies have revealed that CO and CO_2 concentrations are slightly below the prescribed levels. The rise in tricycle ownership in the city, particularly the popular "tokunbo" keke or used keke (with highly inefficient combustion engines) and the ubiquitous nature of commercial tricycles ("keke"), could have exacerbated the situation [50].According to their study conducted in Kaduna and Abuja, districts with considerable traffic congestion it had a greater CO_2 concentration. They found compelling evidence relating higher atmospheric carbon concentrations to more congested areas such as Kubwa, Deidei, Dutse, Maraba in Abuja as well as Kaduna metropolis.

Table 2. Effects of Common Air Pollutants from Tricycles on Human Health

Pollutants	**Health consequences that can be quantified**	**Effects on health that aren't quantifiable**	**Additional possible outcomes**
Sulphur dioxide	Exercise-induced asthmatic morbidity: pulmonary function changes Respiratory symptoms		Non-asthmatic hospital admissions with respiratory symptoms
Particulate matter /TSP/sulphates	Mortality Bronchitis can be chronic or acute. Days off work due to minor RAD chest ailment Asthma symptoms are moderate or severe	Pulmonary Function Changes	Other chronic bronchitis, chronic respiratory illnesses are common as well as Lung inflammation
Carbon monoxide	Congestive heart failure shortened the time it took for angina to develop	Behavioral consequences Admissions to other medical facilities	Developmental implications on the cardiovascular system
Nitrogen oxide	Ailment of the lungs	Responsiveness of the airway	Reduced pulmonary function is a condition in which the ability to breathe is reduced. Lung inflammation Immunological alterations
Lead	Hypertension and Death Coronary artery disease (CAD) that is not fatal IQ loss as a	Other cardiovascular illnesses that affect neurobehavioral function Effects on reproduction Effects of maternal exposure	

	result of nonfatal strokes	on the fetus. Children's delinquent and antisocial behavior	

Source: VTPI (2013)[45]

In the same vein, [51] believes that CO, SO_2, and NO_2 concentrations, as well as total suspended particulates (TSP), are at their highest levels in three Nigerian cities: Lagos, Ibadan, and Ado-Ekiti, all of which are located in the country's South-West region, with Lagos having CO concentrations of 233ppm at Ikorodu, SO_2 2.9 ppm at Ikorodu, and $NO_2$1.5ppm at Ibadan , CO and SO_2 levels were highest at 271 and 1.44 ppm respectively and NO_2 levels were highest at 1.0 ppm in Ibadan. The greatest CO_2-levels were recorded with 317 ppm, NO_2 of 0.6 ppm and SO_2 of 0.8 ppm in Ado-Ekiti.

They discovered that the obtained CO, SO_2, NO_2, and particulate counts per minute were higher than the FEPA limits. CO 10 ppm, SO_2 0.01 ppm, and $NO_2$0.04-0.06 ppm are the limits set by FEPA. The noise levels were found to be higher than the FEPA limit of 90 dB and the WHO limit of 70 dB – 75 dB in all of the locations [52]. According to the findings, there is an increasing risk of traffic-related issues in Nigerian cities, as well as a demand for serious air quality measures. In their study on traffic congestion in Nigeria's major cities, [53] recommended that this may be possible given the large amount of pollution emitted by tricycles on congested routes in Nigeria cities, with over 97% of public trucks, buses, minivans, public tricycles, and motorcycles causing pollution exposure through inhalation of emitted substances by road users as shown above in Figure 3.

3. 2. Air Pollutants form Tricycles and their Effects on the Environment

Table 3. Pollutants from Tricycles: A Summary of Health Concerns

Pollutants	Environmental Effects	References
Nitrogen dioxide (NO_2)	Rain that is acidic. Haze. Eutrophication causes changes in aquatic ecosystems. Precursor of ozone at ground level	[51]
Carbon dioxide (CO_2)	Global warming is caused by greenhouse gases.	[56]
Particulate matter (PM)	Global warming and ocean acidification	[32]
Sulphur dioxide (SO_2)	Acid rain and haze cause environmental damage and ecosystem disruption	[57]
Carbon monoxide (CO)	Global Warming and Climate Change	[49]

Hydrocarbons (HC)	Contribution to the creation of ozone, smells, and some direct effects on structures and plants.	[45]
Lead (Pb)	Pollution of groundwater and airborne particles	[42]

In today's world, air pollution is a significant issue. Ambient air pollution has been linked to a variety of health outcomes, ranging from minor transient changes in the respiratory tract to pulmonary function impairment, restricted activity/performance, emergency room visits, hospital admissions, and mortality. Air pollution is also having an increasingly negative impact on the cardiovascular system [54]. Health-related physical damage functions (mortality and disability).In several nations, estimates of morbidity due to air pollution levels have been made over a number of years.

Although the net effect of pollutants on health is unknown, the Committee on the Medical Effects of Air Pollution (COMEAP), established by the United Kingdom (UK) government, has discovered that particulates (PM), sulphur dioxide (SO_2), and ozone (O_3) have the strongest link between health and pollution [55] as shown in Table 3. Carbon monoxide, hydrocarbons, nitrogen oxides, and fine particles are all produced in large numbers by tricycles. Tricycles are a major emitter of lead into the urban air if adulterated fuel is used. The negative health and some of the sections that follow summarize the environmental consequences of these pollutants:

4. CONCLUSION

According to the study, pollutants released by tricycles can have serious health repercussions, particularly for road users and those living nearby. Tricycle emissions directly or indirectly endanger the environment and the lives of road users, and tricycle emissions and other associated activities carried out along Nigerian highways continue to be sources of these pollutants. This means that the emissions from tricycles on this road are significant, with potentially harmful health repercussions. As a result, there is a pressing need to re-evaluate everything on a regular basis and analyze the effects of keke-emitted fumes in order to avoid the harm that such emissions can cause to human health and the environment. As the fumes of CO, N_2O, SO_2, CH_4, H_2S, PM, S_2O, Pb, and VOCs were found to be above NAAQS and FMEnv in the study, indicating that the ambient air around Nigerian towns and cities was polluted.

RECOMMENDATION

Based on the pollution levels, health, and environmental effects presented in this study, it recommends that;

i. There should be formulation of regulations and establishment of a monitoring program to reduce vehicular emissions and protect the health of road users on Nigerian roadways.
ii. Encouraging the commercial manufacturing of tricycles that use alternative energy sources such as electricity and biofuel, as these will result in lower GHG emissions.

iii. A research program for alternative fuel sources for road transportation should be launched.
iv. Tree planting, particularly along transportation corridors, should promote urban afforestation.
v. The government should implement this to aid in environmental preservation by absorbing CO_2 emitted by tricycles on Nigerian roads.

References

[1] Hubacek K, Guan D, Barua A. Changing lifestyles and consumption patterns in developing countries: a scenario analysis forChina and India. *Futures,* 2007, 39: 1084-1096

[2] Wei YM, Liu LC, Fan Y, Wu G. 2007. The impact of lifestyle on energy use and CO_2 emission: an empirical analysis of China's residents. *Energy Policy,* 2007, 35, 247-257

[3] Akpan U. Impact of regional road infrastructure improvement on intra-regional trade in ECOWAS. *Afr. Dev. Rev.* 2014, 26 (S1): 64-76

[4] Singh SK. Future mobility in India: implications for energy demand and CO2 emission. *Transp. Policy* 2006, 13: 398-412

[5] IEA. Enabling low-carbon end-use. Retrieved September 13, 2014, from InternationalEnergy Agency: 2012, http://www.iea.org/media/etp/FactsheetETP2012EndUseSector.pdf

[6] Khan MY, Tian F. 2018. Understanding the potential sources and environmental impacts of dissolved and suspended organic carbon in the diversified RamgangaRiver, Ganges Basin, India. *Proceedings of the International Association of Hydrological Sciences*, 2018, 379: 61-66. doi:10.5194/piahs-379-61-2018

[7] United Nations. Population Newsletter.Department of Economic and Social Affairs/ Population Division, 2006. www.unpopulation.org

[8] Aluko A. The impact of urbanization on housing development: The lagos experience, Nigeria. *Ethiopian Journal of Environmental Studies and Management,* 2010, 3(3): 64–74

[9] Eyankware MO, Eyankware RO, Okoeguale B.O, Eyankware EO. The Impact of Increase in Urbanization on Major Cities in Nigeria.A Case Study of Enugu State (Enugu Urban), Southeastern Nigeria. *International Journal of Innovational and Scientific Research,* 2015, 14 (1): 32-38

[10] Grieshop AP, Boland D, Reynolds CCO, Gouge B, Apte JS, Rogak SN, Kandlikar M. 2012. Modelling air pollutant emissions from Indian auto-rickshaws, model development and implications for fleet emission rate estimates. *Atmospheric Environment*, 2012, 50: 148-156

[11] Rajkumar. 1999. Effect of air pollution on Respiratory system of auto rickshaw drivers in Delhi.

[12] Onursal B, Gautam SP. Vehicle air pollution: Experiences from seven Latin American urban centre. Technical paper, 373.1997, Washington DC: World Bank.

[13] Ojolo SJ, Oke SA, Dinrifo RR, Eboda FY. 2007. A survey on the effects of vehicle emissionson human health in Nigeria. *Journal of Rural and Tropical Public Health,* 2007, (6): 16-23

[14] Sydbom A, Blomberg A, Pamia S, Stenfors N, Sandstrom T, Dahlen SE. Health Effects of Diesel Exhaust Emissions. European Respiratory Journal, 2001, 7(4): 733-746.

[15] Brunekreef B. Out of American commentary occupation. *Environmental Medicine,* 2005, 62: 351-352

[16] Savile SB. Automotive options and quality management in developing countries. *Indian Journal of Environmental Health* 1993, 16: 20-32

[17] Han X, Naeher LP. A review of traffic-related air pollution exposure assessment studies in the developing world. *Environment International,* 2006, 32: 106-120

[18] C. E. Ekpenyong, E. O. Ettebong, E. E. Akpan, T. K. Samson and N. E. Daniel. Urban City Transportation Mode and Respiratory Health Effect of Air Pollution: A Cross-Sectional Study among Transit and Non-Transit Workers in Nigeria. *BMJ Open,* Vol. 2, No. 5, 2012. doi:10.1136/bmjopen-2012-001253

[19] Abam FI, Unachukwu GO. Vehicular Emissions and Air Quality Standards in Nigeria. *European Journal of Scientific Research,* 2009, 34(4): 550-560

[20] Njoku K, Rumide TJ, Akinola MO, Adesuyi AA, Jolaoso AO. Ambient air quality monitoring in metropolitan city of Lagos, Nigeria. *Journal of Applied Sciences and Environmental Management,* 2016, 20(1): 178-185

[21] Chizoruo IF, Iheanyichukwu OA, Chukwuemeka NP, Ikechukwu AJ. Ambient Air Quality Assessment of Orlu, Southeastern, Nigeria. *Journal of Applied Sciences* 2017, 17(9): 441-457

[22] Scheepers PT, Bos RP. (1992). Combustion of diesel fuel from a toxicological perspective. I. Origin of incomplete combustion products. *International Archives of Occupational and Environmental Health* 1992, 64 (3): 149-161

[23] Kampa M, Castanas E. Human health effects of air pollution. *Environmental Pollution,* 2007, 2151(2): 362-367. doi: 10.1016/j.envpol.2007.06.012.

[24] Afroz AB, Manujushree S, Amrutha SI. A Comparative Study among the Three Wheeler Automobile Drivers on Pulmonary Function Tests in Adult Males of Gulbarga City. *International Journal of Medical Research and Health Sciences* 2012; 2(1): 35-39

[25] Dooyema CA. Outbreak of fatal childhood lead poisoning related to artisanal gold mining in Northwestern Nigeria, 2010. *Environ. Health Perspect* 2012, 120 (4): 601-607

[26] Oghenegare EE, Eyankware MO, Ulkapa ROE. Advances in carbon capture, utilization and storage (CCUS): State of the Art. *Inwascon Technology Magazine,* 2020, (2): 26-37

[27] Acaps, NIGERIA Floods, 2018.

[28] Bissadu KD, Koglo YS, Johnson DB, Akpoti K. Coarse scale remote sensing and GIS evaluation of rainfall and anthropogenic land use changes on soil erosion inNasarawa State, Nigeria, West Africa. *J. Geosci. Geomat.* 2017 5 (6): 259-266

[29] Idowu AP, Adagunodo ER, Esimai OA, Idowu PA. Development of a web based environmental health tracking system for Nigeria. *Int. J. Inf. Technol.Comput. Sci.* 2012, 4 (7): 61-71

[30] Okafor GC, Ogbu KN. Assessment of the impact of climate change on thefreshwater availability of Kaduna River basin, Nigeria. *J. Water Land Dev.* 2018, 38 (1): 105-114

[31] Idowu OO.Challenges of urbanization and urban growth in Nigeria. *Am. J.Sustain. Cities Soc.* 2013, 1 (2): 79-95

[32] IHME, Nigeria, Institute for Health Metrics and Evaluation, 2020. http://www.healthdata.org/nigeria.accessed Mar. 04, 2020.

[33] Ezebilo EE, Animasaun ED. Public-private sector partnership in householdwaste management as perceived by residents in southwest Nigeria. *Waste Manag. Res.* 2012, 30 (8): 781-788

[34] Ugbebor JN, LongJohn IP. Impact of Vehicular Traffic on Ambient Air Quality in Selected Junctions in Port Harcourt, Nigeria. *Science World Journal* 2018, 13(4): 39-43

[35] Ulakpa WC, Eyankware EO, Eyankware, MO, Eyankware, ROU. Evaluation of radionuclides in Eliozu dumpsite, Obio-Akpor LGA South-South Nigeria. *International Journal of Science and Healthcare Research*, 2016, 1(2): 15-22

[36] Okonkwo S, Kenneth O, Mary FO. Assessment of automobile induced pollution in an urban area (A case study of Port-Harcourt city, Rivers State, Nigeria). *Chemical and Processing Engineering Research*, 2014, 25, 12-15

[37] Alexander IA, Ya MG, Yalwa MG, Alhassan AJ, Nels RO, Nelson NO, Muhammad IU. Determination of Lead and some Parameters of Oxidative Stress in Exhaust Fume in Relation to Age in Commercial Tricyclistsin Kano Municipal in Commercial Tricyclistsin Kano Municipal. *International Journal of Medical Science and Applied Biosciences* 2017, 2(2): 11-35.

[38] Modinah AO, Kamaldeen OA, Olarenwaju AA. An Assessment of Vehicular Emissions and Related Health Impactsalong Ilorin-Lagos Highway in Nigeria. *Annals of Science and Technology - B*, 2019, 4 (2): 78-87

[39] Babatola O. Major cities and their regions - Lagos, Africa Atlases. Les Éditions J.A. Paris: 2002, 132-133

[40] Kpaka V. Proliferation of natural gas vehicle in Nigeria - The way forward 2003, www.vanguardngr.com/articles/2002/business/b730092003.html

[41] Eyankware, M. O., Eyankware, RO. Environmental degradation on land in Enyigba with reference to artisan lead-zinc mine in South Eastern Nigeria. *Journal of Multidisciplinary Scientific Research*, 2015, 3 (3), 32-34

[42] Alfred J, Hyeladi A. Assessment of Vehicular Emission and Health Impacts in Jos, Plateau State. *Journal of Research in Environmental Science and Toxicology*, 2013, (2): 80-86

[43] Babanyara, Y.Y., Usman, H.A. and Saleh, U.F. An overview of urban poverty andenvironmental problems in Nigeria. *J. Hum. Ecol.* 2010, 31 (2): 135-143

[44] Oguntoke O, Yussuf AS. Air pollution arising from automobile emissions and the associated human health problems in Abeokuta Metropolis, Nigeria. *Asset*, 2008, 8 (2): 119-132

[45] VTPI, 2013.

[46] Enemari, E Vehicular emissions: Environmental and health implications. National Conference on the Phase-out Leaded Gasoline in Nigeria. Abuja, Nigeria, 2001

[47] Omenikolo AI, Uduma CI, Chinekeokwu T, Abara JC. Assessment of air pollution generated by transport in Owerri, South East, Nigeria. *Merit Research Journal of Environmental Science and Toxicology*, 2017, 5(1): 9-17

[48] Joseph AA, Terrumun A, Tor- A, Ishaq, SE. Assessment of some Gaseous Emissions in Traffic Areas in Markurdi Metropolis, Benue State, Nigeria. *Open Journal of Air Pollution*, 2015, (4): 175-183.

[49] Ndoke PN, Jimoh OD. Impact of Traffic Emission on Air Quality in a Developing City of Nigeria.Department of Civil engineering, Federal University of Technology, Minna, Niger State. 2007, http://www. enginpro.blogspot.com/2007/07/impact-of-traffic-emission-on-air.html

[50] Okhimamhe AA, Okelola OF. Assessment of Carbon Dioxide Emission at Road Junctions in the Southeast of Niger State, Nigeria. *Alam Cipta*, 2013, 6 (2): 59-70

[51] Osuntogun, B. A. and Koku, C. A.: Environmental impacts of urban road transportation in South-Western states of Nigeria. *Journal of Applied Sciences*, 2007, 7(16): 2356-2360

[52] Ojukwu CP, Okemuo AJ, Madu CV, Ativie RN, Caesar CS, Moris AE. Pulmonary functions of commercial tricyclists (Keke Napep riders) in Enugu State, Nigeria. *Afr Health Sci*. 2020; 20(2): 798-805. doi:10.4314/ahs.v20i2.33

[53] Kayode, O., 2015. Evaluative Traffic Congestion in developing Countries. A case study of Nigeria. Paper presented at the 2015 Chartered Institute of Logistics and Transport (CILT) Africa Forum Held at Mount Meru Hotel, Arusha, Tanzania 1-28.

[54] Ojukwu CP, Okemuo AJ, Madu CV, Ativie RN, Caesar CS, Moris AE. Pulmonary functions of commercial tricyclists (KekeNapep riders) in Enugu State, Nigeria. Afri Health Sci. 2020; 20(2): 798-805. https://doi.org/10.4314/ahs.v20i2.33.

[55] Hirsch J. Automotive trends in aluminum - the European perspective. *Materials Forum* 2004, (28): 17-21

[56] Ulakpa ROE, Eyankware MO. Contamination assessment of water resources around waste dumpsites in Abakaliki, Nigeria; A Mini Review. *Journal Clean WAS*, 2021, 5(1): 13-16

[57] Eyankware MO, Ephraim BE. A comprehensive review of water quality monitoring and assessment in Delta State, Southern Part of Nigeria. *Journal of Environmental & Earth Sciences* 2021, 3(1): 16-28

[58] Kalpakjian S Schmidt SR. Manufacturing Engineering andTechnology. 5th ed. Chicago: Pearson Prentice Hall; 2006, 156-210.

[59] Eyankware MO, Ulakpa ROE, Eyankware OE. (2016). Assessment of impact of leachate on soil physicochemical parameters in the vicinity of Eliozu dumpsite, Port Harcourt, Nigeria. *Basic Research Journal of Soil and Environmental Science,* 2016, 4 (2): 15-25

[60] Hartmut A. Auto-Electric Basic Technology—Part 1. German: Namibian project. 1997, 10-30

[61] Rajput RK. Automobile Engineering. 1st ed. New Delhi: Laxmi Publications (P), Ltd; 2007, 1(57): 401-560