Review

iMedPub Journals
www.imedpub.com

Clinical Pharmacology & Toxicology Journal

2018
Vol.2 No.1:5

Trends of Ambient Air Pollution and the Corresponding Respiratory Diseases in Addis Ababa

Mekonnen Maschal Tarekegn[1*] and Tigist Yohannes Gulilat[2]

[1]Department of Environmental and Climate Change Management, Collage Urban Development and Engineering, Ethiopian Civil Service University, Addis Ababa, Ethiopia

[2]Collage of Health Sciences, Tikur Anbesa Specialised Hospital, Addis Ababa University, Addis Ababa, Ethiopia

[*]**Corresponding author:** Mekonnen Maschal Tarekegn, Department of Environmental and Climate Change Management, Collage Urban Development and Engineering, Ethiopian Civil Service University, Addis Ababa, Ethiopia, Tel: +251-091-187 97 18; E-mail: maschalm12@gmail.com

Received: 20 January 2018; **Accepted:** 02 February 2018; **Published:** 28 February 2018

Citation: Tarekegn MM, Gulilat TY (2018) Trends of Ambient Air Pollution and the Corresponding Respiratory Diseases in Addis Ababa. Res Rep Clin Pharmacol Toxicol Jour Vol.2 No.1: 5

Abstract

In this review paper, emission potentials of transport sector, common air pollution linked incidents and air pollutant concentration are assessed. A desk review of open access articles and secondary data from stakeholders integrated with key informant interview has been used. Accordingly, the rapidly increasing transport sectors together with the fast urbanization, poorly and slowly constructing road infrastructure and the type and quality of high sulfur containing fuel usage are the major derivers of Addis Ababa air quality degradation. Literatures have reported concentration of $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO and Pb are 280 µg/m^3, 285 µg/m^3, 20 µg/m^3, 97 ppm, <45 ppb, <0.10 µg/m^3 and 2.8 ppm, respectively; which are quite greater than the tolerable limit of WHO [1] air quality guideline.

Acute upper respiratory infection increased with annual growth rate 47.18% from incidents 4539 (2003) to 212590 (2017). The chronic obstructive pulmonary disease (COPD) and Pneumonia are being increased by annual growth rate about 53.44% and 24.89%, respectively. Also, there are several other or unspecified diseases of the respiratory system are currently being recorded at healthcare centers.

In general, the increasing trends and nature of respiratory diseases are clearly attributed to the increasing vehicles and corresponding emissions. In addition to this, the nature and accessibility road, quality of fuel and type and quality of vehicles used in Addis Ababa affected emission rate and its corresponding incidents. Finally, improving the quality of vehicular fuel, focusing mass transport services, discouraging old car import and improving road infrastructure are suggested.

Keywords: Particulate matter; Nitrogen Oxide; Sulfur Dioxide; Pneumonia; Asthma; Bronchitis

Introduction

The quality of air is now becoming a serious issue of cities. The death of 6.5 million people worldwide is linked with air pollution. More than 11% of the deaths were related to air pollution [2]. As it was justified in 2017, more than 25% of the >5 years age children deaths are associated unclean air quality. The PM_{10}, NO_x and other volatile organic carbon (VOC) in urban air are found to be exceeded than WHO guideline limit. The major sources of these pollutants in the city are transport, industries and other services like waste management and household energy.

The rapid increase in urban population due to the natural causes and urbanization aggravate the issue in the developing country than the industrialized world. The increased population of cities demand higher service sectors, transportation, industries and energy which in turn emit more air pollutants into the surrounding atmosphere [3].

Addis Ababa is experiencing a higher population growth due to higher rate of urbanization and rural to urban migration. The city has a population of 2.7 million with a growth rate of 2.1% [4]. The increasing population derived a change in land use from natural to build environment. The city is expanding laterally to the North Western and both at the North Eastern and South Eastern parts. The increased population and city expansion demands higher transportation services. Accordingly, higher number of mass transport services as well as small vehicles has been emplaced.

The construction activities are increased from time to time. Roads, real states, industries and other investments are being constructed. As a result, the air quality in the city is highly affected by emissions from transport, dust from traffic road, emission from industrial activities, construction operations, and other overall land use practices. The air quality has become a serious concern in the city. The mass concentrations of total suspended particulate matter in the city were beyond the WHO safe guideline value of 150 µg/m^3 [5].

As it was also noted by Kumie [6], the outdoor air pollutant's (CO, PM_{10}, NO_x and $PM_{2.5}$) concentrations near and on the road sides were above 50% of the world health guideline limit. As it was reported in Tefera et al. [7] studies on outdoor air pollution with respect to Addis Ababa are rather limited.

However, the adverse impact of air pollution on health and other socioeconomic activities are well studied by different scholars. Zhang et al. (2015) [8] and German International Cooperation Energy Coordination Office [9] have studied that $PM_{2.5}$ and NO_x have the ability to go through the lung's defensive barrier and to affect the alveoli. These pollutants irritate the mucosal membrane of the respiratory organs and affect defenses that indirectly increase the risk of infection.

Liu et al. [10] reported that the exposure of $PM_{2.5}$ causes inflammations which may initiate other cardiovascular diseases. Recent epidemiological and experimental evidences showed that there is a clear link between air pollution and diabetic diseases. Findings showed that air pollution is a persistent factor for type 2 diabetes.

The adverse impact of air pollution on environment and health for which it has threaten the living conditions of human beings and existence of all creatures in the world in well understood by the international community at global level. Several multilateral organizations have passed agreements and addressed the reduction of greenhouse gasses, ozone depleting gasses and release of highly toxic persistence organic compounds.

Many countries including Ethiopia agreed and signed an agreement to reduce emission of these gaseous pollutants. Kyoto protocol, Montreal protocol, Stockholm convention, Copenhagen Summit, South Africa Summit and Paris Agreement are some of the multilateral agreements that Ethiopia has taken the lead and signed at the forefront. Accordingly, Ethiopian environmental policy has been crafted to address the environmental issues including pollution. Various legislations including proclamations, regulation and standard guidelines have also been developed.

However, issue was understood properly and, environmentalist and epidemiologist have studied its effect intensively; and also noticed by WHO and policy makers, the problem is aggravated in developing country related to the increasing industrialization and rate of urbanization. As previous studies indicated, ambient air pollution is getting serious in developing countries like Ethiopia where an increasing motorization, high rate of urbanization and industrial expansion are present.

Despite there are limited number of studies specific to air pollution to Addis Ababa, from the literatures conducted from other part of Ethiopia and data of air pollution drivers it is possible to suspect higher air pollutant emission to the air pollution. Like soil and water pollution, air pollution is not being regulated by Addis Ababa EPA.

There are limited monitoring technologies, relevant expertise and weak institutional setup to regulate air pollution in Addis Ababa. There are no enough air pollution literatures that supplement government policy makers' decisions. The inadequacy of technical information and weak policy and strategy makes the problem to continue as business as usual. The purpose of this review paper is to compile outdoor related articles, journal reports, government reports and air pollution models so as to generate policy information for decision makers to take strategic actions.

Objectives

To assess the trends of transport sector including the growth of vehicles number, conditions of road infrastructure, type and quality of fuels imported and currently is being used by the motorized transport services. The vehicles to road ratio are also assessed to estimate the extent of air pollutant emission from the transport sectors.

To identify the air pollution related respiratory incidents recorded in Addis Ababa city health centers, clinics and hospitals. The review assesses the type and nature of diseases recorded for the last 5 years of which the HMIS have been started and the health related data properly handled, and draw an incident based trend lines.

To assess the gaseous pollutant concentration of the atmosphere in the city, the study explores information of $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO and Pb concentrations of the air for Addis Ababa city.

To explore and forward possible suggestions to reduce or solve the air quality problems of the city, the reviewer has compiled several possible experiences of air pollution management and sustainable mitigation measures of other countries and forward to be implemented for Addis Ababa city air pollution management.

Methodology

In this paper, review of literatures and related secondary data were used to synthesize the information. Related peer reviewed articles were compiled online from reputable journals and secondary data were collected from relevant government offices.

Desk review

A systematic review of relevant peer reviewed research articles and related literature has been done. A peer reviews articles have been downloaded online from the reputable journals. Relevant standard literatures were taken from WHO, multilateral organizations like IPCC, UNEP and etc. Then, the articles and standard literatures have been read critically to synthesize the information.

Secondary data

Relevant secondary data have been collected from various Ministries, Federal and Regional offices such as Ministry of Environment, Forest and Climate Change, Federal Transport office, Addis Ababa Health birroue, Addis Ababa Transport birroue and Addis Ababa Environmental Protection Authority.

Key informant interview with experts of the government offices was also conducted. The secondary data was analyzed, information was extracted, and the report was synthesized and used as supplementary of reviewed literature.

Review of Literature

Various multilateral agreements have been passed international levels to manage and reduce air pollution from industries and service sectors. Also, several studies have been conducted on the air pollution in various dimensions. The source of air pollution, the degree of pollutant concentration, impacts and its management measures have be researched by various scholars. Articles and multilateral organization approaches on air pollution PM, NOx, SOx, O_3 and some persistent organic pollutants are reflected. International conventions and multilateral agreements, national policies, legislations and guidelines which govern reduction of air pollutants are also discussed below.

Global environmental regimes

The Stockholm declaration principle 1: The principles declared in Stockholm states that *"Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future".*

This statement succinctly describes that development should not come at the expense of environmental degradations in general air quality deterioration in particular.

Principles in Agenda 21 provide options for combating degradation air quality. It deals with balancing excessive consumption, health and education, cities and environmental degradation. It recognized that sustainable development is the way to reverse both poverty and environmental destruction.

Rio Declaration was agreed that environment and development should be going together without separately. Environmental safeguarding shall comprise a vital part of the development process to achieve sustainable development. Hence, the declaration further states that higher quality of life for all people in the world cannot be achieved with unsustainable mode of manufacturing and utilization, so that an indigenous people and the local communities have a fundamental role in environmental management and development.

Helsinki protocol reduction of sulfur emissions - it was in the 1985, a commitment for reduction of sulfur gasses emissions reduction has been agreed. The protocol has noticed that air pollutants are causing an extensive damage, in Europe and North America, on resources of economic importance such as forests, soils and waters, and to materials (including historical monument) and also have detrimental effects on human health.

So in the protocol they priorities actions to aware the fact of predominant sources of the pollutants, considering priority of technologies and actions reducing sulfur emissions, recalling the decision of the United Nations Economic Commission for Europe (ECE) at its thirty-ninth session, which stresses the urgency of intensifying efforts to arrive at coordinated national strategies and policies in the ECE region to reduce sulfur emissions effectively at national levels, recalling the recognition of Executive Body for the Convention at its first session of the need to decrease at a set of standards, noting the convention contracting Parties on implementation of reductions of their national annual sulfur emissions or their trans boundary fluxes by at least 30 per cent as soon as possible and others.

Stockholm convention on persistent organic pollutants: One of a global, legally binding instrument aimed at protecting human health and environment across the world from the harmful impact of persistent organic pollutant. The convention was adopted at conference held from 22 to 23 may 2001, in Stockholm Sweden. Accordingly, the convention has agreed to best understanding to eliminate dangerous pops, support the transition to safer alternatives, target additional POPs for action, clean up old stockpiles and equipment containing pops; and work together for POPs- free nature. Regarding to the convention, Ethiopia has been proclaimed the ratification of this convention on 2nd day July 2002, Proclamation No. 279/2002 which is the Stockholm Convention on Persistence Organic Pollutant.

Geneva protocol of volatile organic compounds (VOC): The protocol was adopted on 18 November 1991 in Geneva, to control emission of volatile organic gasses or their Trans boundary fluxes. It targets the decrease of VOC, a major air pollutant responsible for the formation of ground-level ozone. To reduce VOC emission, the Protocol has put options like (i) 30% reduction in emissions of VOC by 1999 using a baseline standard of year between 1984 and 1990, (ii) similar reduction as for (i) within a Tropospheric Ozone Management Area (TOMA) and make sure that by 1999 entire national release do not exceed the 1988 levels and (iii) Finally, where emissions in 1988 did not exceed certain specified levels, Parties may opt for a stabilization at that level of emission by 1999. Again in 1996, the decision-making Body adjusts the Protocol in 1996 concerning issues to control technologies for emissions of VOCs from off-road vehicles and machines, ships and aircraft.

National Environmental Regimes

Policy framework

Ethiopia's environmental policy: Ethiopia has adopted the Constitution in 1995. This Constitution provides the basic and comprehensive principles and guidelines for environmental protection and management. Among other things the Constitution states that everyone has the right to live in a clean and healthy environment and the government will make every effort to provide such an environment. The Environmental Policy of Ethiopia (EPE) was approved by the Council of Ministers in April 1997. It has 11 sectoral and 11 cross-sectoral components. Its preparation was based on the

policy and strategy findings and recommendations of the Conservation Strategy of Ethiopia. The policy document contains elements that state the importance of mainstreaming socio-ecological dimensions in development programs and projects. In line with EPE, the Government of Ethiopia has issued several sectoral and cross-sectoral policies and godliness that consider environmental issues for sustainable development. Among these, the ones which are most relevant are described below.

Ethiopian population policy: This Policy was issued in April 1993 and aims at closing the gap between high population growth and low economic productivity through a planned reduction in population growth combined with an increase in economic returns. With specific reference to natural resources, the main objectives of National Population Policy are: making population and economic growth compatible and the over-exploitation of natural resources unnecessary; ensuring spatially balanced population distribution patterns, with a view to maintaining environmental security and extending the scope of development activities; and Maintaining and improving the accommodating capacity of the environment by taking appropriate environmental protection and conservation measures.

Ethiopia's health policy: Ethiopia's health policy was issued in 1993, with the aim of giving special attention to women and children, to neglected regions and segments of the population, and to victims of man-made disasters. The priority areas of the policy are in the field of Information Education and Communication (IEC) of health towards health issues, epidemics, and diseases that are related to poor living condition and exposure with severe environments.

Regulatory framework

The Council of Ministers Regulation No 159/2008 introduced industrial pollution prevention regulations. This Regulation (Council of Ministers, 2008) has seen the light of the day after six years since the adoption of the parent legislation, which is Proclamation No 300/2002 (FDRE, 2002).

Proclamation on Environmental Impact Assessment (Proc. No. 299/2002) was issued in December 2002 with the aim to make an EIA mandatory for specified categories of activities undertaken a either by the public or private sectors are to ensure EIA as a legal tool for environmental planning, management and monitoring. The Proclamation elaborates on considerations several positive and negative impacts including the assessment of gaseous pollutants into the atmosphere.

Proclamation on Establishment of Environmental Protection Organs (Proc. No. 295/2002) came into effect in 2002 and its objective was to assign responsibilities to separate organizations for environmental development and management activities on one hand, and environmental protection, regulations and monitoring on the other, in order to ensure sustainable use of environmental resources, thereby avoiding possible conflicts of interest and duplication of effort. It is also intended to establish a system that fosters coordinated differentiated responsibilities among environmental protection agencies at federal and regional levels. The Proclamation re-established the EPA as an autonomous public institution of the FDRE. It also empowers every Sector Ministry or Agency to establish or designate an Environmental Unit (Sectoral Environmental Unit) that shall be responsible for coordination and follow-up.

Proclamation on Environmental Pollution Control (Proc. No. 300/2002), is mainly based on the right of each citizen to have a healthy environment, as well as on the obligation to protect the environment of the Country and its primary objective is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed, and to make the violation of these standards a punishable act. The Proclamation states that the "polluter pays" principle will be applied to all persons. Under this proclamation, the EPA is given the mandate for the creation of the function of Environmental Inspectors. These inspectors are given the authority to ensure implementation and enforcement of environmental standards and related requirements.

Proclamation on Public Health (Proc. No. 200/2000) entered into force as of March 9, 2000. Objectives of the Proclamation include enhancing popular participation in implementing the country's health sector policy, promoting attitudinal changes through primary health care approach and promoting healthy environment for the future generation.

Institutional framework

The Federal Democratic Republic of Ethiopia (FDRE) was formally established on August 21, 1995. The FDRE comprises of the Federal States with nine Regional State members. The new government structure takes power from the center to regions and localities. The relative roles of government at the different levels (Federal, Regional and Local) in terms of power and duties, including on fiscal matters, have been defined by the Constitution, Proclamations Nos. 33 of 1992, 41 of 1993, and 4 of 1995. Under these proclamations, duties and responsibilities of Regional States include planning, directing and developing social and economic programs, as well as the administration, development and protection of environment in their respective regions. These regional agencies have basic administrative units in lower administrative units at Woredas and Kebele levels; however, it is failed to achieve in some regions.

The Proclamation No. 295/2002 derived establishment environmental unit at federal level. Hence, a sectoral environmental unit has been established to ensure the harmony with respect to implementation of the environmental proclamations and other environmental protection requirements. The Environmental Protection unit re-established in the form of Ministry of Environment, Forest and Climate Change in 2013 as an autonomous public institution of the Federal Government of Ethiopia entrusted with the protection of Environment.

The general role of the Ministry is to provide for the protection and conservation of the broad environment,

through formulation of policies, strategies, laws and standards, which foster social and economic development in a manner that enhance the welfare of humans and the safety of the environment sustainable.

Ambient air pollution trends

Anthropogenic air pollution has a mixture of different toxic substances in the atmosphere. As it was described in Norman et al. [11] and Hezhong Tian [12], the commonly found air pollutants in the polluted ambient air are oxides of sulfur, oxides of nitrogen, lead (Pb), ozone, volatile organic compounds and suspended organic compounds. The same report indicated that Nitrogen Dioxide (NO_2) is one of the highly reactive gases also called NO_x primarily emitted from cars, trucks and buses, power plants, and off-road equipment exhaust. Ozone is not emitted directly to the air but it is created from the chemical reactions of nitrogen oxides and volatile organic compounds in the presence of air.

Motor vehicle exhaust, gasoline vapors, and chemical solvents that are essentially becoming the major sources of NO_x and VOC contributing tropospheric ozone formation. Suspended particulate matter commonly known as mixture of fine solid particles and liquid droplets in the air; such as dust, soot, or smoke has a size of 10 micrometers or 2.5 micrometers are commonly produced from unpaved roads, constructions sites and automobile exhaust. Carbon monoxide is also one of the toxic ambient air pollutants commonly emitted from cars, trucks and other vehicles or machinery that burn fossil fuels.

However, its sources are different from one area to the other lead majorly emitted to the atmosphere from ore and metal processing and burning of leaded automobile fuel. The USEPA reported largest sources of SO_2 emissions are from fossil fuel combustion at power plants and other industrial facilities; however other vehicles and heavy equipment that burn fuel with high sulfur content also emits at small scale level.

The rapid increase in motorized transport in urban area of developed nations pose air pollutions related problems. The study conducted on six metropolitan cities of South Africa indicated the outdoor air pollution contribute to cause of 3.7% national morbidity from cardiovascular disease and 5.1% of diseases attributed to cancer due to trachea, bronchus and lungs; so that the traffic related air pollution has become the focus of concerns [11].

As it was reported in Stewart [13], air pollution was a serious issue of London in 1952; so that it took the government hand to initiate legislative measures which would see the beginning of the end of such regular winter miseries. According to the author, over 4000 deaths were recorded from respiratory and chest diseases. In the United State of America, the number of individuals with asthma grew by 75 percent between 1980 and 1994, making asthma one of the few diseases whose incidence and death rates continue to increase despite broad-based medical advances in control and treatment; this was attributed to the over deposition of suspended particulate matter and ground based ozone in the air [14].

Haze and fog crises have overwhelmed the Chinese urban residents in recent years [15]. The air pollution heavily affects the life quality, damages the respiratory system, and reduces the welfare of society [3,16]. In 2014, the $PM_{2.5}$ indexes of the top-ten polluted cities in China were above 100 units, which was 5 times higher than the top-ten polluted cities of United States and much higher than the WHO standard value. Among the 74 cities of China that are detected the $PM_{2.5}$ index, more than half of them belong to “the severely polluted rank”, and more than 20 cities belong to “the most heavily polluted rank”. The air pollution problem has drawn more and more attention of the public and even provoked the concerns of the global world [17].

In 2014, the prime minister of China declared that there would be a protracted war and a tough battle with haze and fog pollution. Particulate matter (PM) including the fine particle ($PM_{2.5}$) is the main component of air pollution [18].

The transport sector appears a main energy consumer in China [19], and almost 50% of the PM in the urban air comes from traffic emissions [20,21]. Hence, the increasing emissions from urban transportation become the key factor contributing to the air pollution in most cities of China. There are two main reasons for the PM emissions increase from urban traffic. On one hand, the annual growth rate of the car ownership in China has been more than 10% since 2000.

On the other hand, the growth of urban traffic infrastructure investment is relatively lagging behind. As shown in **Figure 1**, from 2002 to 2014, the annual growth rate of road area in China was much lower than the annual growth rate of automobile ownership. The imbalance of urban transport investment infrastructure and the residents' automobile consumption leads to more serious traffic congestions.

The rapid urbanization and huge investment in transport and other services sectors has been recorded in Addis Ababa city for the recent years. As it was reported in Addis Ababa Transport Authority report, about 70% of the vehicles are found in the Addis Ababa.

According to the report the rate of vehicles growth in the city is 9.88%. The same report indicated that the rate of asphalt road growth in the city is about 8.28%. In 2016, the city administration has a total of 2626 km of asphalt road, 1433 km Gravel road and 1866 km Cobbled road as a total of 5915 km road infrastructure. However, the total vehicles to Asphalt road length ratio of 171; which is very difficult traffic congestion that can create severe pollution related problems, huge consumption of fuel and toxicity issues of pollutants on humans. Hence, the traffic related pollution issue is a major concern of Addis Ababa city.

The increasing economic activity and residents mobility along the street makes the traffic congestion and air pollution to be more worsen in the city. Street venders, road side

shoppers, drivers, commuters, pedestrians, traffic police, and residents are increased in vicinity of road networks.

Study reported by Etyemezian et al. [22], the 24-hourly PM_{10} and 8-hr average of CO concentration of the ambient air were below permissible limits; however, the annual PM_{10} concentrations exceeded the guideline. It was also found that the PM_{10} level was ranged from 35 to 97 $\mu g/m^3$ and its maximum peak for 1-hr average CO concentrations was less than 7 ppm. Despite all these facts, the samples were taken 50 to 100 meters away from Main Street had its own error. The study noticed that urban infrastructure in Ethiopia is insufficient to accommodate rapidly increasing number of vehicles. As of information from Addis Ababa Road Authority [23], a one-lane street with 3.5 to 4.0 meters width is common in most of the city.

Vehicles are being driven with an average speed about 20-30 km per hour, particularly at peak hours at 7.50-9: 00 am and 14: 00-19: 00 pm. Uniquely topography of Addis Ababa city varied slop between 0.5%-12.0%, so that the vehicles repeatedly changing its acceleration and deceleration. This process affects the fuel using efficiency of the engine that indirectly increases emissions into the atmosphere.

Air pollution, and its economic and health impacts

A USEPA in its standard has declared that various outdoor and indoor air pollutants are toxic to human health and to the environment when they are released above their tolerable limits. According to USEPA, breathing ozone can cause a variety of health problems, predominantly for children, the elderly, and people of all ages who have lung diseases such as asthma. It can also affect vegetation and ecosystem; elevated CO levels in outdoors can trigger heart disease for people by reducing ability for getting oxygenated blood to their hearts in conditions when their heart demands more oxygen than usual especially during exercising or under stress.

As it described by USEPA, lead get in to the body and is accumulated in the bones and replace calcium and cause cancer. It also adversely affects the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood.

In other side, breathing air with a high NO_2 concentration can irritate airways in the human respiratory system. The other air pollutant, SO_2 can also harm the human respiratory system and make breathing complicated. Particularly, children, the aged, and those people who suffer from asthma are very sensitive to effects of SO_2 gasses pollutant. At high concentration, it forms a strong acid and damage plants and other economic infrastructure.

The particulate matter either primarily emitted into the atmosphere or produced as secondary pollutant in the air at different sizes affect breath system of human beings. According to WHO [1], all air pollutants have their own maximum tolerable limits and they affect human health if they are beyond their permissible quantity. Also, the effect of each pollutant is also depended on its exposure time limits; small concentration of pollutant even may affect human health if it expose for long time.

According to the Ministry of Environment, Forester and Climate Change; Ethiopia has adopted the maximum exposure and emission limits of air pollutant from WHO guideline limits.

The pollutant concentration in the air should not be greater than the WHO guideline limits **(Table 1).**

Table 1 WHO air quality guidelines [1].

Pollutant	Average Time	Concentration (µg/m3/or ppm)
PM10	Annual mean	20 µg/m3
	24 hour mean	50 µg/m3
PM2.5	Annual mean	10 µg/m3
	24 hour mean	25 µg/m3
O3	8 hour mean	100 µg/m3
NO2	Annual mean	40 µg/m3
	1 hour mean	200 µg/m3
SO2	24 hour mean	20 µg/m3
	10 minutes mean	500 µg/m3
CO	15	90 ppm
	30	50 ppm
	1 hour	25 ppm
	8 hour	10 ppm
Pb	Annual mean	0.5 µg/m3

Simkhovich et al. [24] and Bell et al. [25] have reported three possible exposure pathways of air pollutants. These pathways are provocation of systemic inflammation and/or oxidative stress, the activation of autonomic nervous system; and the translocation into the circulation with the potential for direct effects on homeostasis and cardiovascular integrity. However, the type and amount of inhaled pollutants affect the relative importance of each mechanism.

First, the inhaled air pollutants promote the release of a variety of pro-oxidative/inflammatory (cytokines, activated immune cells, or platelets) and/or vasoactive mediators (endothelin) into the systemic circulation and trigger systemic inflammation, atherosclerosis, and endothelial dysfunction. Secondly, the accumulation of air pollutants to the pulmonary tree stimulates lung nerve reflexes leading to systemic autonomic imbalance that subsequently favors vasoconstriction and raises of HRV.

Finally, the inhalation of some metallic components and very small PM of the air pollutants might be able to pass through the alveolar capillary membrane reaching directly into the system. The ability of pollutant to pass in each pathway is affected by its size and charge, the chemical composition, and

the propensity to form aggregates determine the ability to cross the lung–blood barrier [24].

The report of Vietnam Ministry of Natural Resource and Environment accessed online provided further evidence between air pollution and respiratory diseases. According to the report, percentage of respiratory disease cases of people living in the urban area of Vietnam were highly affected [26]. In Hanoi; one of the polluted cities of Vietnam, the poor, children and old people in the central urban areas were the most damaged and unable to cope with the severe air pollution. Pneumonia, Chronic Bronchitis and Throat symptoms are the most frequently occurring air born incidents in the city. According to Hung, the incomes of Vietnam were reduced by 20% and disease incidents of citizen were also increased by 20% due to air pollution.

The research was conducted in five areas namely ThuongDinh Industrial zone, PhapVan highway, DongXuan Market, KimLien apartment quarter and TayHo; and More than 2,200 households with 10,100 members, 6,020 students, and 1,370 workers were surveyed. About 73% of the household were suffered from illnesses due to air pollution. A Vietnam Register (VR) and Swiss-Vietnamese Clean Air Program (SVCAP) had estimated Vietnam was losing about one billion Vietnam dong/day (eq. 50.000 USD/day) because of air pollution.

Similar to other developing countries, air pollution due to transportation has become a major attention in Ethiopia. The rate of urbanization is increasing fatly from time to time. The natural and rural-urban migration is significantly increasing the urban population which indirectly demands the urban transport facility. Various studies indicated the growth of private and freight mobility in Addis Ababa have expanded the role of transport as a source of emission of pollutants and their multiple impacts on the natural environment.

Despite its large number of motor vehicles, the city is characterized by high levels of traffic congestion which is responsible for high gas emissions and large proportion of particulates posing a major threat to human health and natural resources of the surrounding area (AATA, 2017).

As reported by Tefera et al. [7] and Hailu et al. [27] traffic-related air pollution in Addis Ababa both at the wet and dry season showed higher pollution load. The trends of PM_{10}, CO and O_3 mass concentrations at 40 sampling locations of 20 roads at 6:00 pm have been investigated and found that the dry months (January/February) PM_{10} mass concentrations measured in the urban areas were higher (<100 µg/m^3) than those in the sub-urban areas (40 µg/m^3). However, the PM_{10} lead (Pb) concentrations of all samples were <0.1 µg/m^3; an implication of government banning import of leaded gasoline [6].

As it was mentioned in the same report, less than 45 ppb of O_3 was measured near the mid-day. A study has also found the measured quantity of particulate nitrogen oxides for PM_{10} in the urban and sub urban setting was <5% and 7%, respectively [22].

It was also noted in Gebre et al. [5] the mean value of total suspended particulate matter (TSP) was about 195 µg/m^3, which is above the WHO safe guideline value (120 µg/m^3). In contrast, PM_{10} concentration studied in Gebre et al. [5] was measured within the range of 17-285 µg/m^3; which is less than the WHO guideline. The peak value of CO concentration that was measured early in the mornings and late in the afternoons and about 15% of study samples at the roadside and all (100%) on-road samples CO concentration were greater than WHO guideline value [6]. All authors have concluded that ambient air pollutants concentration is above the WHO guideline tolerable limits.

Case Study: Transport and Air Pollution Trends in Addis Ababa

The rapid and high diplomatic and industrial development of the country has attracted not only domestic and international companies, but also rural communities into the capital city. The population in the city is increasing from time to time. Addis Ababa city with an estimated population of 3.6 million is considered as a major metropolitan city by any developing country standard. Population explosion and the associated anthropogenic activities generate huge amounts of different types of wastes (air, solid and gaseous) that adversely affect the physical environment. The transport services are a public sector that is being demanded by the increasing population in the city.

Correspondingly, emission of pollutants is increased rapidly. Respiratory diseases are incidents commonly recorded at the health care institutions like health centers, clinics and hospitals. The common driving forces, pressures, states, impacts and responses for air pollution issue in Addis Ababa is summarized in the DPSIR diagram **(Figure 1),** discussed below.

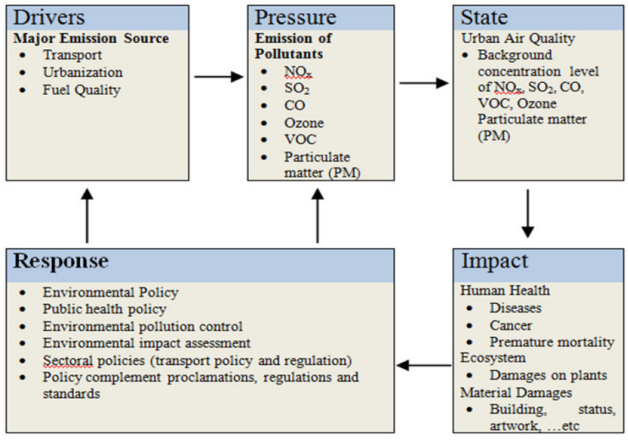

Figure 1 DPSIR diagram for air pollution in Addis Ababa.

Driving forces

Urban transport and mobility conditions in Addis Ababa: Urban transport in Addis Ababa is carried by a mixture of ownership structures, of which Public and Private Entities are

predominantly contenders for business. According to AATA, the mode of urban transport system in the city can be classified as motorized and non-motorized traffic, of which the former one which owned by both the government and private entities include public bus, mid-bus, mini-bus, and lower vehicles (saloon taxi) with 100, 27, 11, and 4 passengers carrying capacity respectively. Presently, city buses, taxes and private vehicles altogether account 30% of the urban mobility i.e. 26% (buses), 72% (taxes) and 4% (private cars) **(Figure 2)**.

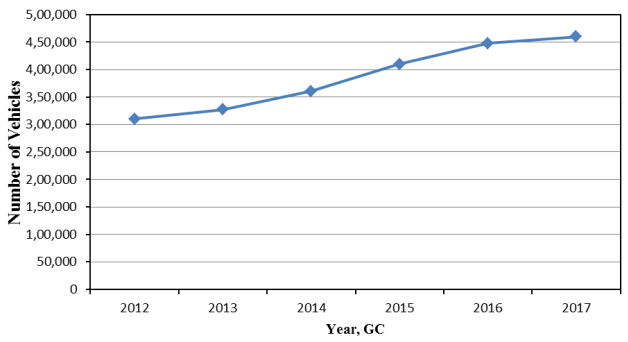

Figure 2 Vehicle increment trends in Addis Ababa. (AATA, 2017).

Road condition of Addis Ababa: The inadequate road network system in Addis Ababa has its own environmental consequences, as it directly affects urban mobility and thereby increasing traffic congestion which in turn paves for high carbon emissions from vehicles. In spite of change in its network coverage, its percentage was still below the international road infrastructure standard (25%). As it is indicated in **Table 2**, the total road network coverage of the city in 2016 is 22.16% which was below the international city standard of road network infrastructure.

Table 2 Trend of road network coverage from 2011 to 2016.

Road Literacy	Unit (Km)	Year (2011-2016)					
		2011	2012	2013	2014	2015	2016
Asphalt road	Km	1758	1807	2002	2165	2443	2616
Gravel road	Km	1687	1777	1419	1330	1596	1433
Cobbled	Km	67	147	727	1176	1326	1866
Total Road length	Km	3512	3731	4148	4671	5365	5915
Coverage	%	12.9	13.7	15.64	17.5	20.1	22.16

Road network growth versus vehicles

The current total road network of the city over is which 40% of vehicles were on roads of 5915 kms, which is inadequate compared to the number of vehicles situated in the city **(Table 3)**. The data showed that about 168 vehicles are available at every 1 km distance travelled in the city. A short appraisal conducted by Addis Ababa Transport Authority, more than 100 vehicles was practically counted in Addis Ababa asphalt. Assuming that all vehicles in the city are simultaneously on the roads, it is possible to count about 168 vehicles at every 1 km road.

As a result of this, it occupies a space or emits pollutant gasses and affects the quality of ambient air. Moreover, the increasing rate of road dependent motorized vehicles in Addis Ababa is greater than growth rate of asphalt road (with 7 meters width) construction in the last five consecutive fiscal years [28]. So, traffic related air pollution gets aggravated from time to time.

Table 3 Total number of vehicles: Road networks and Vehicle to Road length ratio.

Year	Total Road Network (km)	Total Vehicles	Vehicles/km
2012	1807	310,180	172
2013	2002	326,994	163
2014	2165	360,869	167
2015	2443	410,101	168
2016	2616	447,669	171
Total Mean Vehicles/Km		168	

As it is clearly presented in **Figure 3**, about a rate of 9.88% per year of vehicles growth rate are recorded, while the growth of asphalt road is about 8.28%, which is below the average growing rate of vehicles in the past five consecutive years. The difference in the rate of growth between asphalt road and vehicles in the city during the last five years is about 1.6%. If this gap continued for about 10 years, the difference in the rate of growth will reach 4.8% by 2026.

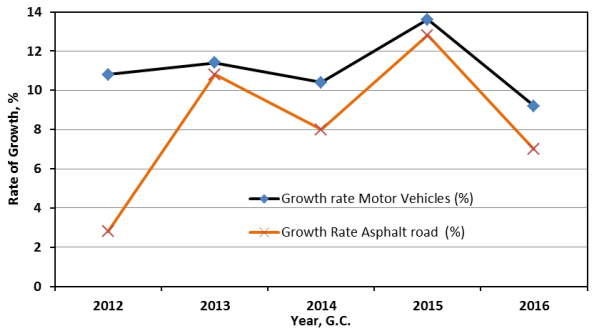

Figure 3 Vehicles and Asphalt roads growth rate in% from 2012–2016 (AATA, 2016) [28].

Nature and level of fuel consumption: Despite the sophisticated vehicle emission control technology, the quality of the fuel consumed is critical to environmental impact of transportation. Recent studies indicated that the nature of fuel

alone determines the environmental impact of vehicular emission. To this end, the quality and amount of fuel consumed are among the dominant factors which determine the GHG and pollutant emissions from motor vehicles.

As research by Demis A. [29], about 90% of freight and 95% of the passenger transport in Ethiopia happened by road vehicles which are reported to consume 65% of imported fossil fuels. According to Demi [29], on the Sectoral background and Energy consumption, diesel & gasoline are the main fuels used in transport sector in Addis Ababa.

As presented in **Table 4**, the sulfur content of fuel imported to Ethiopia is very high that is 1000 ppm and 5000 ppm for both gasoline and diesel respectively.

Parallel to the current growth rate of motorized vehicles in Ethiopia in general & Addis Ababa in particular, the level of fuel consumption (in liter) is also increasing from year to year. A report found from Addis Ababa Transport Authority (AATA) indicated the fuel consumption has increased from 695,806,717 liter in 2011 to 1,349,014,573 liters by 2016 **(Table 4).**

Table 4 Fuel consumed in Addis Ababa (2011-2016).

Year	Amount consumed in liter
2012	695,806,717
2013	821,051,917
2014	968,841,262
2015	1,143,232,689
2016	1,349,014,573
Consumed	995,589,432

Urbanization: Addis Ababa is a rapidly urbanizing city **(Figure 2)** which leads to an increased population. In 2007, Addis Ababa has approximately 2.7 million registered inhabitants with a population density of 3,740 persons/km2 and 2.1% population growth rate [4]. Currently its projected population reached to 3.6 million. However, the actual population is estimated to be more than 5.0 million if unregistered inhabitants are included. This creates heavy pressures on the environments and urban infrastructure.

In Addis Ababa, air pollution is particularly caused by traffic, industries and domestic activities [5,7]. Therefore, they are the direct driving forces for the urban air pollution which can potentially cause severe damages to human health and natural functioning of the environment. The demanding additional transport services with rapidly increasing population is the main driving force affecting urban air pollution. It has been estimated that approximately 70%-75% of air pollutants of PM_{10}, SO_2, NO_X, and CO comes from traffic [12].

It also causes problems of immigration; and traffic congestion and it creates demand for more public services which put even more pressure on the air environment **(Figure 4)**.

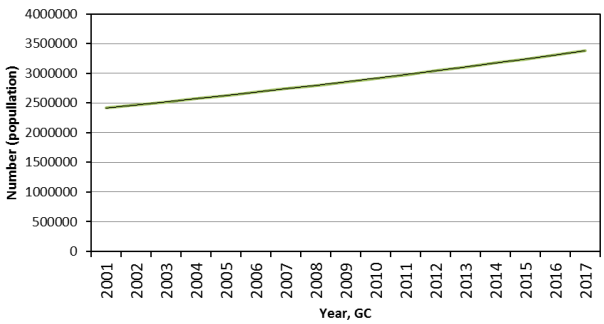

Figure 4 Population Growth Trends of Addis Ababa City (2001-1017); Projected from CSA (2007); $PT=P0e^{RT/100}$, R-rate of population growth=2.1%, T- Time (year).

Pressure of air pollution in Addis Ababa: As shown in the DPSIR diagram, the pressures are air pollutants emitted from different sources. The major emissions considered as air pollutant in Addis Ababa are Total Suspended Particles (TSP), NO_X, CO, VOC and SO_2. The emissions derived from each driving forces explained are pressures of air quality **(Table 5).**

Table 5 Pressures of air pollution in Addis Ababa.

Pollutant	Concentrations	Source
NO_2	97 ppm	Kume (2009)
SO_2	20 μg/m^3	Kume (2009)
CO	2.8 ppm	Kume
PM_{10}	285 μg/m^3	Gebre et al.
$PM_{2.5}$	280 μg/m^3	Tefera et al.
O_3	<45 PPB	Etyemezian et al.
Pb (Lead)	<0.1 μg/m^3	Tefera et al.

State of air pollution in Addis Ababa: The state of concentration of air pollutants (PM, NO_X, CO, SO_2 and VOC) in the air is analyzed by measured pressure data. In Addis Ababa, the air quality is measured only at two monitoring stations. The monitoring stations are managed by the US Embassy in Addis Ababa. However, Addis Ababa Environmental Protection Authority is a lead agency mandated to regulate and manage air quality in the city. The station is measuring online and released data for public.

As shown in **Figure 5**, the $PM_{2.5}$ concentration of Addis Ababa air is at moderate state with maximum concentration 157-176 ppm and minimum concentration 30-38 ppm. According to the US EPA air quality index standards [30], the atmospheric concentration of $PM_{2.5}$ in the city is unhealthy state.

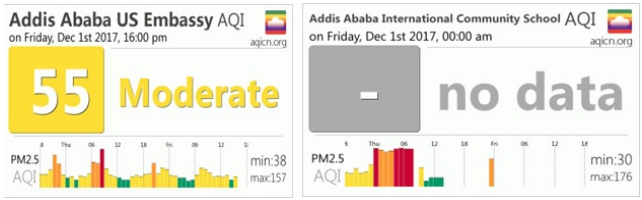

Figure 5 $PM_{2.5}$ State of the atmosphere in Addis Ababa (Addis Ababa US Embassy Air Quality Monitoring Site, 2017).

Impacts of air pollution in Addis Ababa: The most serious impact of urban air pollution is damage to human health [1]. People living in urban areas are exposed to air pollutions which seriously affect their health. In Addis Ababa, poor people and children in the central urban areas are the most damaged group of society by air pollution [31]. The children and old people also has difficulty in coping with air pollution. Exposure to air pollution may cause various diseases. Long time exposure to air pollutions causes respiratory disease, throat inflammation, cardiovascular disease, chest pain, and congestion.

According to Addis Ababa City Health Birroue health management information system report acute upper respiratory infections, acute bronchitis, asthma, chronic obstructive pulmonary disease (COPD), pneumonia, and other unspecified district or region specific respiratory diseases are increasingly recorded in the last five years. The prevalence of these respiratory diseases is alertly increasing from time to time **(Figure 6).**

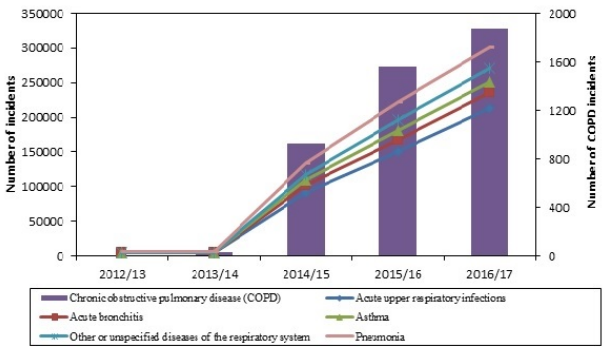

Figure 6 Air Pollution related respiratory Disease in Addis Ababa (AAHB, 2017).

Response to air pollution in Addis Ababa: As define earlier, the responses are the actions that government and others take to mitigate the negative changes of urban air pollution. Responses can be legal works that can prevent urban air pollutions. It could be regulated by setting standards for emissions of vehicular activities such as developing standards for fuel used, cleaning the emitted air by introducing catalytic converters on cars, introducing environmentally friendly cars e.g. hybrid cars. Ambient air quality standards are built-up to protect the state of the environment from air pollutants like: TSP, PM_{10}, SO_2, NO_2, and CO.

In general, the response is the governmental policies of managing emissions and air quality in urban areas and city authorities' effort in urban planning towards an environmentally friendly and sustainable development of cities. In response to the awareness of the negative effects of air pollution on the social and economic development, the Ethiopian government has issued a system of policies relevant to air quality management.

Policy and legal framework: The Constitution of the Federal Democratic Republic of Ethiopia provides a favorable policy environment for air quality (Article 44/1). In the Constitution, all persons are granted fundamental rights to have a clean and healthy environment. The government's share of responsibility in ensuring the right of citizens to live in a healthy environment is also stated in the Constitution. In addition, environmental policy which outlines the activities needed to prevent pollution of land, air, and water in cost-effective ways is issued. Recognition has also been given to the salient role water resources play in meeting the country's energy demand. A more encouraging environment has also been created to promote training and improve the working conditions of researchers under the specific objective of preventing pollution.

The transport policy of Addis Ababa: The city government has crafted a policy for providing comfortable, safe, dependable, efficient, equitable transport service for the city of Addis Ababa to accelerate development, and make a competent city on regional, continental and international levels including the environmental protection and energy use. In the policy, the government has prepared a laws and enforcement mechanisms to ensure integration of environment protection in the transport services. Improving the imported fuel quality to ensure the diesel is free from lead. On the other hand, to take care of emission and noise pollution from vehicles, as well as environmental pollutions created during road construction and maintenance. Actions were also taken for blending of petrol with renewable sources of energy.

Transport service plan and strategies: Based on the idea of transport policy, a transport plan was prepared to reduce the aforementioned air pollution related problems. The plan address the objective to contribute for sustainable environmental protection, by establishing clean, healthy and safe transport system; to develop positive impacts by mitigating the influence of transport infrastructure construction, maintenance and service on environmental protection and to encourage application of transport technologies that use renewable energy source and that are fuel saving.

Several strategic actions were proposed by the Ethiopian government transport sector. Limit ages of imported vehicles so as to reduce or avoid air pollution in the transport service; improve fuel quality and use fuel substitute energy sources, employ vehicles technical inspection, implement clean

development mechanism, training and awareness creation about the influences of transport service on environment; formulate emission standards and implement necessary control.

In addition, Addis Ababa Transport birroue consider the preparation and implementation of standards and legal framework to reduce the noise and air pollution in the transport sector. Expanding mass transport so as to reduce traffic congestion and air pollution is taken as an action. A priorities of measurable actions was also identified by a concerned bodies, establishment of institutional coordination and preparation of action plan; enforce high ethanol-blended fuel consumption of imported vehicles, introduce incentives, regulation formulation and implementation; ensure high biodiesel-mix consumption of imported diesel vehicles to enable biodiesel for transport service, prepare incentives for importing fully biodiesel vehicles.

However, there is no transport related environmental protection proclamation crafted, several related legislations were emplaced to mitigate the problem. Some of them are Proclamation on Environmental Impact Assessment: Proclamation (Proc. No. 299/2002), Proclamation on Establishment of Environmental Protection Organs: This Proclamation (No. 295/2002), Proclamation on Environmental Pollution Control: Proclamation, Proc. No. 300/2002 and Proclamation on Public Health: Public Health Proclamation (No. 200/2000) can be mentioned.

Discussion

Urban air pollution due to vehicular emissions has become an issue of global concern WHO [1]. The World Health Organization evaluated the extent of urban air pollution according to four main indicators namely PM_{10}, NO_2, SO_2, and troposphere ozone in 24 mega cities of the world. In this review, the degree of ambient air pollution in Addis Ababa and other developing cities have been seen by 5 indicators including carbon monoxide.

The major causes of potential air pollutants in urban settings of Ethiopia are attributed to traffic (vehicular) exhausts. Unlike other cities in Ethiopia, Addis Ababa has high traffic and population density coupled with industrial concentration and commercial activities. The city is currently undergoing rapid urbanization with huge expansion in transport sectors with the purpose of increasing the road network and the associated quality of transport service. Several studies indicated that the population and economic growth in the city has led to rapid urbanization and increasing mobility demand culminating in rapid motorization. As it has been stated population growth, urbanization and of course the recent growth in the GDP has resulted in the rise of motorized vehicles ownership. The WHO [1] also confirms that the recent phenomena in the growth of economy have led to the rise in the automobile ownership, growth in the size of vehicles in developing country.

The number of vehicles is growing from time to time both at national and regional (city) level item. More significantly, and of the total 100% vehicles in Ethiopia, almost 70% are found in Addis Ababa. The number of vehicles is increasing alarmingly in the city of Addis Ababa from year to year. As reported by AATA (2016) [28], the number of vehicles in the city is increasing to 447,669 (2016). This number has been increased by average growth rate of 9.88%; the number of vehicles in 2012 was 310,180. As far as the areal density of vehicles (based on 2016), about 829 vehicles are available per square kilometer area of the city. Hence, the spatial distribution of vehicles in the city showed overcrowded conditions which exert externalities on the environmental quality of the city.

The unbalanced growth in number of vehicles and road construction also aggravates traffic congestion and delays in the movement of people and goods, increased fuel consumption, and reduced efficiency of personal and business movement, increased GHG and pollutant emission, and deterioration of the quality of the surrounding air.

The road network condition of the city is also affects the emission levels of pollutants from motorized transport of Addis Ababa city. According to Addis Ababa Transport authority report (2016) [28] the currently available asphalt road network (2616 km) is not enough to accommodate the rapidly increasing number of vehicles in the city. Currently, the vehicles to asphalt road length ratio is about 168. This implied that about 168 vehicles are found on 1 km of the asphalt road; which is disastrously releasing air pollutants to the air. The rate of vehicles growth is faster than the rate of road network investment and upgrade. The data from the transport authority showed that the mean annual vehicles growth is 9.88% while the road network increases only by rate of 8.28%.

The nature and type of fuel consumed is also a factor that affects air pollutant emission level of vehicles. The continued import of high sulfur fuels in to the country without improvement seems to increase the pollution [29] Similar author has indicated that the exponential increase of vehicles using high sulfur content in fuel will result in growing environmental & human health problems, huge national economic loss and burden associated with clearing up existing vehicles.

Major pollutants like PM_{10}, NO_2, SO_2, troposphere ozone and CO have been recorded for a maximum level of 285 $\mu g/m^3$, 97 ppm, 20 $\mu g/m^3$, <45 ppb, and 2.8 ppm/15 min. respectively of pollutants **(Table 5).** The concentration of these pollutants (PM_{10}, NO_2, SO_2, troposphere ozone and CO) are quite greater than WHO [1] standards of respective tolerable concentration 20 $\mu g/m^3$, 40 $\mu g/m^3$, 20 $\mu g/m^3$, 100 $\mu g/m^3$ and 90 ppm/15 minutes. These concentrations of air pollutants are more aggravated in the dry season. Various studies has confirmed that annual particulate matter in the developing country cities have similar trends. The ambient air pollutant concentration is often exceeding 4-5 times to the WHO guidelines [1]. Cairo had the highest PM_{10}, nearly 150 $\mu g/m^3$ while Johannesburg and Cape Town had >40 $\mu g/m^3$. Developing countries must learn from previous experiences in Europe and America where increased hospital admissions and deaths occurred due to ambient air pollution in the 1950's and 1960's. The 1952 two-week crisis of excess 4000 deaths in

London was due to coal burning and traffic pollution that resulted in high level of ambient air pollution including on the traffic lines. World health organization forwarded a good reason why this could happen in African cities where there is an increasing use of low standard over used vehicles. As of the developing country cities, an increasing number of used low standard vehicles are being observed.

In the other side, the total GHG emissions from on-road transportation in Addis Ababa in 2012 were estimated to be 1,412,432 tCO_2e [32]. The author has noted that the private passenger cars contribute almost half of the total transportation emissions (42%). This reflects the rapid economic growth of the city and increasing income of the population, which has driven an increase in private car ownership. About 31% of scope 1 emission are from buses and shared transport [32].

Similarly, a report on air pollution in Addis Ababa demonstrated approximately 50% of the cities vehicles produced a pollutant composition about 90% of the hydrocarbon (HC) and carbon monoxide (CO) emissions. Further, the same report confirmed that concentration of particulate matter (PM) level in the city's ambient air was at least 11 times, on average, higher than comparable United States of America (USA) and world health organization (WHO) standards [32].

The continuous utilization of huge volume of fossil fuels affects not only the socio-economic condition of surrounding but also the health society in the city. Similar research reported by V. Safe (2015), most of the light duty vehicles in the city is older than 15 years and beyond their useful service life. As a result, high fuel consumption and emission of pollutants can prevail and cause environmental risk in Addis Ababa. It is scientifically accepted that vehicles with 15 years old can produce four to five times more pollutants than the new ones. The number of vehicles taken away each year from the city's road is also very low.

Emissions from these vehicles contain a variety of toxic chemicals especially lead from batteries and leaded petrol as a major source of environmental contamination in the inner city environment. Having recognized the existence of these problems in the city, the effect of vehicular emissions has not been given due attention. Hence, comprehensive studies have not yet been carried out on the type of air pollutants, their level of pollution and potential impacts to evaluate the status of traffic pollution in the city level with the exception of some studies focusing only on certain areas in the city.

Many factors interact to affect the amount of vehicular emission sources. The type of fuel (petrol or diesel), the efficiency of internal combustions, the driving velocity (idle, fast or slow), the topography of road (uphill, downhill or plain), the age of the vehicle, temperature changes on the surface of the earth and weather conditions such as wind velocity, its strength and direction are some of the factors that determine vehicular emissions. According to the AACGRA, the average speed of vehicles in Addis Ababa is about 20-30 km per hour on many roads, especially at peak hours during 7.50-9: 00 am and 14: 00-19: 00 pm, and the topography in city has a slope variation between 0.5 and 12.0% to affect the speed and use of fuel in order to increase vehicular emissions on the city road.

A sample study conducted by Addis Ababa city transport authority (2016) to assess the concentration of lead in High Traffic Density (Stadium to Kaliti)- Medium Traffic density (Piaza to Arat Kilo) - Low traffic density (Kara Kore) - areas of Addis Ababa have shown that the concentration of lead was 9.11, 6.90 and 5.36 µm/g of soil respectively. The heavy metal deposition trends in the soil sampled from the road surrounding indicated that vehicular emission is the major pollutant source of lead for the city air.

The result has proved that areas with high traffic densities will have the highest concentration of lead. The elevated levels of Pb in soils of high traffic density at Addis Abba are therefore due to vehicular emissions and the concentration will also increase with the increase in the vehicles. From this perspective, the decision passed not to use leaded petrol (>0.013 g/L) for vehicles in Addis Ababa since 2004 is a good indicative measure for reducing the impact of vehicular pollution due to lead emission.

A key informant interview at Addis Ababa Transport Birroue showed that several actions were taken to reduce the environmental impact of transportation system in the city. Accordingly, various promotion activities in the area of transport sector were conducted so as to enhance public transport, reduce traffic congestions; improve road networks, and the avoidance of using old cars (fuel inefficient vehicle), relocation of heavy truck terminals out of the city center to Kality. This can be taken as positive measures to minimize air pollution in the city as a result of vehicular emissions. However, there is still luck of promotion on public awareness on the conservation and efficient utilization of energy resources with aim of reducing urban air pollution. Also, development Plan has proposed the promotion of public transport to reduce vehicular air pollution; however, measureable work has not been in place in the area.

As it was reported by Addis Ababa Health birroue [28], air pollution related respiratory diseases are increased alertly. Acute upper respiratory disease is an infection caused by air pollution that may interfere with normal breathing system and affects both the upper and lower respiratory stem. According to the report, such infections has been stepwise increased from 4539 (2003) to 212590 (2017). It has been increased by an average rate of 47.18% per year. Similarly, acute bronchitis was increased annually by 55.62%. Respiratory diseases like Chronic obstructive pulmonary disease (COPD) and Pneumonia are also common incidents that seriously affecting the population of Addis Ababa City.

The rate of annual growth of chronic obstructive pulmonary disease (COPD) in Addis Ababa is about 53.44%. Only 8 incidents were recorded in 2013 for the first time and then increased to 1871 incidents by 2017. The number of pneumonia incidents was 575 (2013); that it is increased to 29844 incidents by 2017. Also, there are several other or

unspecified diseases of the respiratory system that commonly recoded in the health care centers of Addis Ababa city; its number of incidents is rapidly increasing from year to year **(Figure 6).**

In general, the increasing number of health incidents in the city forwards a direct implication of transportation service development trends in the city; could have been caused by ambient air pollution. A very serious and payable attention is required to save the health living environment in the city. It is important to expect more increasing pattern of traffic air pollution due to the growing traffic density and the deteriorating quality of urban road infrastructure. The growth observed in the number of vehicles (e.g., an increase at a rate of 9.88% or about 4500 vehicles a year) calls for the need to monitor near-road ambient air quality in the cities.

Conclusion

This review pointed out the major driving forces that pose a pressure on the air quality Addis Ababa and potentially recorded adverse impacts of air pollution that commonly observed in the health centers, clinics and hospitals of the city. Experiences of other developing and developed country cities are also reviewed. Accordingly, the major driving forces from ambient air pollution in Addis Ababa are transport and urbanization with its increasing regular and irregular economic activities. The population is increasing alertly. Related to this, motorized transportation system is correspondingly increased.

The rate of vehicular increase is beyond the affording capacity of road network that are being built. The number of vehicles is being increased by 9.88% annually, whereas the road network is increasing with annual growth rate of 8.22%. Accordingly, about 168 vehicles are found in a 1 km single lane asphalt road at a time and initiate more traffic jam, higher fuel conception and more vehicular emission to the environment. Most of the vehicles commonly imported and used are over used low standard cars that can emit more emission to environment.

The acute upper respiratory infections, acute bronchitis, asthma, chronic obstructive pulmonary disease (COPD), Pneumonia, other or unspecified diseases of the respiratory system, district/region specific diseases - 1 and 2 are the very rapidly increasing air pollution related incidents in Addis Ababa.

Also, there is a limitation of regulatory body to regulate the emission of pollutants from the vehicles. Also, information related to pollutant concentrations and its adverse impact is inadequate. There is lower integration of stakeholders like universities, research centers; government authorities lime Environmental protection agency, health buerrue, and transport and road authority. Similar limitations are likely to characterize many countries in the Eastern African Sub region.

Recommendation

Institutional capacity building should be given for the concerned government body to regulate the driving forces of air pollution. Separate department responsible for monitoring and regulating the emission from transport system and other services. Appropriate test center should also be developed to test and the magnitude of pollutant emitted to the environment. The Centre as well as the department should also get trained personnel that can efficiently manipulate the air pollution monitoring technology. Air pollution regulatory instrument should be developed so that it could be implemented by the regulatory agency. The government should give a priority to adjust the organizational structure, budget, and expertise required to manage air pollution.

Appropriate monitoring sites need to be established to regularly monitor ambient air quality in the city. The online kind of air pollution monitoring sites should be selected appropriately by accounting different land use category of the city. Linking the air quality monitoring with routine public information system that can easily classify air quality in different categories based on the severity of the problem.

Creating partnership between academia and implementing/ regulatory organizations to facilitate evidence-based decisions, Improving the awareness and participation of stakeholders like private sectors, non-government sectors and government sectors to get easy solutions.

The government should import a low sulfur content fuel from abroad, Reducing import of higher sulfur containing diesel and number of trucks that commonly uses diesel advisable.

The government should focus to strengthen the mass transport system. Focusing mass public transport is advisable to reduce air pollution from transport. Light rail way and tram transport with electric city as energy option should be done, Revising the transport policies and strategies Opening reference laboratories for air quality monitoring at the national and regional levels.

References

1. World Health Organization (2005) WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Global Update 2005 Summary of Risk Assessment.
2. World Health Organization (2016) Ambient air pollution: a global assessment of exposure and burden of diseases. WHO press.
3. Huang L, Zhou L, Chen J, Chen K, Liu Y, et al. (2016) Acute effects of air pollution on influenza like illness in Nanjing, China: a population-based study. Chemosphere 147: 180-187.
4. Central Statistical Authority (2007) National census report. Addis Ababa, Ethiopia.
5. Gebre G, Feleke Z, Sahle-Demissie E (2010) Mass concentrations and elemental composition of urban atmospheric aerosols in Addis Ababa, Ethiopia. Bull Chem Soc Ethiop 24: 3.
6. Kume A, Charles K, Berehane Y, Anders E, Ali A (2010) Magnitude and variation of traffic air pollution as measured by CO in the City of Addis Ababa, Ethiopia. Ethiop J Health Dev 24: 156-166.

7. Tefera W, Asfaw A, Gilliland F, Worku A, Wondimagegn M, et al. (2016) Indoor and outdoor air pollution- related health problem in Ethiopia: Review of related literature. Ethiop J Health Dev 30: 5-16.
8. Zhang Y, He M, Wu S, Zhu Y, Wang S, et al. (2015) Short-term effects of fine particulate matter and temperature on lung function among healthy college students in Wuhan, China. Int J Environ Res Public Health 12: 7777-7793.
9. German International Cooperation Energy Coordination Office, Energizing Development (2014) Ethiopia Improved Cook Stoves (ICS).
10. Liu C, Ying Z, Harkema J, Sun Q, Rajagopalan S (2013) Epidemiological and experimental links between air pollution and type 2 diabetes. Toxicol Pathol 41: 361-373.
11. Norman R, Cairncross E, Witi J, Bradshaw (2000) Estimating the burden of disease attributable to urban outdoor air pollution in South Africa. S Afr Med J 97: 782-790
12. Tian H, Qiu P, Cheng K, Gao J, Lu L, et al. (2013) Current status and future trends of SO2 and NOx pollution during the 12th FYP period in Guiyang city of China. Atmos Environ 69: 273-280.
13. Stewart KM (1994) Air Pollution: Some Key Issues. J R Soc Promot Health. 114: 86-90.
14. Brown P, Mayer B, Zavestoski S, Luebke T, Mandelbaum J, et al. (2004) Clearing the air and breathing freely: the health politics of air pollution and asthma. Int J Health Serv 34: 39-63.
15. Hao Y, Liu YM (2016) The influential factors of urban PM2.5 concentrations in China: a spatial econometric analysis. J Clean Prod. 112: 1443-1453.
16. Laguna-Torres VA, Gómez J, Ocana V, Aguilar P, Saldarriaga T, et al. (2009). Influenza-like illness sentinel surveillance in Peru. PloS One 4: e6118.
17. Xie Y, Zhao B, Zhang L, Luo R (2015) Spatiotemporal variations of PM2.5 and PM10 concentrations between 31 Chinese cities and their relationships with SO2, NO2, CO and O3. Particuology 20: 141-149.
18. Costa LG, Cole TB, Coburn J, Chang YC, Dao K, et al. (2017) Neurotoxicity of traffic-related air pollution. Neurotoxicology 59: 133-139.
19. Boey A, Su B (2014) Low-carbon transport sectoral development and policy in Hong Kong and Singapore. Energy Procedia 61: 313-317.
20. Briggs DJ, Collins S, Elliott P, Fischer P, Kingham S, et al. (1997). Mapping urban air pollution using GIS: a regression-based approach. Int J Geogr Inf Sci 11: 699-718.
21. Wrobel A, Rokita E, Maenhaut W (2000) Transport of traffic-related aerosols in urban areas. Sci Total Environ 257: 199-211.
22. Etyemezian V, Tesfaye M, Yimer A, Chow JC, Mesfin D, et al. (2005) Results from a pilot-scale air quality study in Addis Ababa, Ethiopia. Atmospheric Environment 39: 7849-7860.
23. Addis Ababa City Government, Addis Ababa Road Authority. (Facts about Addis Ababa City transport Addis Ababa Road Authority.
24. Simkhovich BZ, Kleinman MT, Kloner RA (2008) Air pollution and cardiovascular injury: epidemiology, toxicology, and mechanisms. J Am College Cardiol 52: 719-726.
25. Bell G, Mora S, Greenland P, Tsai M, Gill E, et al. (2008) Association of air pollution exposures and mechanisms. J Am Coll Cardiol 52: 719-726.
26. MONRE (2008) Annual report on National Air Environmental state of 2007. Ministry of Natural Resource and Environment.
27. Hailu W (2015) Climate resilient green growth strategy and integrated climate change response investment Plan for Addis Ababa (Published working report).
28. Addis Ababa City Transport Authority (2016) The trends of transport facilities and its environmental impact. Addis Ababa, Ethiopia (Unpublished report).
29. Demis A (2012) Global Fuel Economy Initiatives (GFI) study in Ethiopia.
30. United State of America Environmental Protection agency (2016) Air quality act.
31. Balakrishnan K, Sambandam S, Ramaswamy P, Mehta S, Smith KR (2004) Exposure assessment for respirable particulates associated with household fuel use in rural districts of Andhra Pradesh, India. J Expo Sci Environ Epidemiol 14: S14.
32. Benjaminson R, Shenkute D (2012) The effect of gasoline fueled vehicles exhaust emission on air pollution in Addis Ababa, Ethiopia (Published working report).