



The Effect of Diesel-Fueled Vehicle Exhaust Smoke Emissions on Air Pollution in Addis Ababa, Ethiopia: Baseline Study



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1. Executive Summary

A 2012 V-SAFE report (Benjaminson & Shankute, 2012) on air pollution in Addis Ababa caused by gasoline-fueled vehicles demonstrated that approximately 50% of the city's vehicles produced about 90% of the hydrocarbon (HC) and carbon monoxide (CO) emissions. Furthermore, the same report confirmed that the concentrations of particulate matter (PM) levels in the city's ambient air was at least eleven (7) times, on average, higher than comparable United States of America (USA) and World Health Organization (WHO) standards.

The report recommended that Addis Ababa's government officials and concerned environmental stakeholders take intervention measures to reduce vehicle pollution, which poses risks to human health and the environment.

Addis Ababa is a fast-changing city whose recent economic growth is one of Africa's success stories. The city attracts tourists, businesses and manufacturing industries that provide employment opportunities to the city dwellers where-by increasing the city's revenue. In addition, the city hosts headquarters of numerous continental and international organizations; and the city is often referred to as the "political capital city of Africa" due to its historical, diplomatic and political significance for the continent of Africa.

Consequently, for the city to uphold its continued significance in Africa and to enjoy sustainable economic development, the city government must reduce vehicle emissions and environmental degradation. Everybody wants to work and live in a clean city. However, visible haze detracts from the clean impression that visitors, investors and customers have.

In 2014/2015, V-SAFE received a grant from the "*Strategic Climate Institutions Programme (SCIP) Fund; the SCIP Fund is financed by DFID UK-Aid, the Royal Norwegian Embassy and the Royal Danish Embassy*", to implement a project entitled "Vehicle Emissions Reduction in Addis Ababa" (Project VERA) in partnership with the Addis Ababa Environmental Protection Authority (AAEPA). The four main objectives of Project VERA included the following:

1. Initiate public awareness media and outreach campaigns,
2. Build a pool of trained and knowledgeable automotive technicians and engineers,
3. Establish a pilot inspection and maintenance (I/M) program, and
4. Perform a diesel-fueled vehicle particulate emissions study.

For the first objective, public awareness campaigns were publicly disseminated through media outlets to raise public awareness of the harm caused by vehicle air pollution. V-SAFE and AAEPA jointly designed audience-targeted media relations, events, speaking engagements, videos, posters, etc. and jointly executed the public awareness campaign.

For the second objective, automotive emissions control technology (ECT) training sessions were provided to over 100 government technicians, academic, and civil society stakeholders. V-SAFE developed the syllabus and conducted the training. The training focused on the operations, diagnoses and repair of automotive engine ECT's. The training provided hands-on knowledge of how harmful exhaust emissions are created when ECT's are not functioning as they are designed. At the same time,

the training demonstrated that when malfunctioning ECT's are properly repaired, then the harmful emissions they create could be eliminated.

For the third objective, a pilot I/M program concept was designed for government implementation. Primarily, V-SAFE developed the conceptual design of the pilot I/M and trained the AAEP staff on it. Then, V-SAFE and AAEP trained other governmental stakeholders from different governmental agencies and together implemented a small-scale pilot I/M.

The fourth objective is the subject of this report. This report quantifies and evaluates the contribution of diesel-fueled vehicle exhaust particulate emissions to the ambient air pollution of Addis Ababa.

Ethiopia's urban air pollution has significant health consequences that strongly correlates to the low average life expectancy of about 59 years (WHO, 2011). The air in Addis Ababa is characterized by high levels of PM and high levels of ozone. Diesel PM emissions are made up of tiny particles that can be inhaled and penetrate deeply into the lungs. PM is a precursor of lung cancer, respiratory and cardiovascular problems, as well as the cause of many environmental issues (CARB, 2011).

Diesel particulate material¹ is responsible for the black smoke traditionally associated with diesel-fueled vehicles. However, worldwide, things have been changing. Over the last twenty years, diesel engine manufacturers have developed new diesel emission control technologies. These technologies are now required and are common on diesel vehicles in many parts of the world. The result is much lower diesel PM emissions than from engines without the new technologies. Because of economic pressures, fleet turn-over, that is, the replacement of old vehicles with new vehicles, is slow in Ethiopia. Additionally, because of a small diesel fleet relative to the city's population (about 500,000 vehicles to 5 million people), the vehicles in the fleet undergo heavy use over long lifetimes. Further, cost-effective engine parts and diesel engine maintenance expertise are not available. The result is that the current diesel fleet in Addis Ababa is primarily made up of old, worn out engines, heavily overloaded, pre-emission-control technologies in an operating environment lacking regular maintenance. As the result, diesel engines in Addis Ababa release black smoke.

When diesel engines do not receive regular preventive maintenance, they can release elevated levels of black smoke. Because of this condition, engines inefficiently consume fuel resulting in monetary waste of purchased fuel by both vehicle owners and the Ethiopian government. A 1996 study in India on "Diesel Smoke and Fuel Consumption" developed a correlation between diesel smoke and fuel consumption (Rogers, 2002). This study applied the correlation to Addis Ababa's diesel-fueled fleet. If the average smoke opacity² value was to drop from 80% to 40%, Addis Ababa could save between 100 million and 200 million Ethiopian Birr, approximately \$5 million to \$10 million USD, yearly in fuel costs alone. This figure does not include cost savings attributed to benefits gained in improved health and quality of life, as well as vegetation, building and other environmental quality benefits.

¹ Diesel Smoke—Particles, including aerosols, suspended in the exhaust stream of a diesel engine which absorb, reflect, or refract light.

² Opacity is the degree to which diesel exhaust smoke blocks light, and the basis for measuring the amount of smoke coming from a diesel-powered vehicle. Poorly maintained or malfunctioning engines are the cause of excessive exhaust smoke.

In addition, diesel smoke, or “soot”, is a major cause of reduced visibility due to the buildup of atmospheric haze, which is characteristic of Addis Ababa’s all-season overcast. The reduced visibility caused by diesel smoke, among many other issues, may have a significant effect on transport safety in Addis Ababa as vehicle operators could experience impaired visibility of other vehicles and surroundings due to the possible interference of high-density soot in the atmosphere. A monthly report that documents major issues that happen in big cities of Africa, in its 2014 release (Zegabi, 2014) stated that Addis Ababa has one of the highest fatality rates per vehicle in the world with a rate more than 100 fatalities per 10,000 vehicles per years. This finding is compared with Kenya and the United Kingdom where the fatality rate per 10,000 vehicles and per year is about 19 and 2, respectively. It is estimated that due to traffic accidents alone, the federal government of Ethiopia loses about 1.3 billion Ethiopian Birr (\$65 million US dollars) annually

Vehicle pollution in Addis Ababa is killing people, destroying health, polluting the city, and wasting money. This and various other studies [Do you have references?] have documented that the current state of Addis Ababa’s ambient air pollution is of great concern. The government must act soon to promote and protect public health and the environment. As a result, along with the invaluable gains achieved in quality of life and the environment, the government can categorically reduce costs in national fuel and health services as well as promote new opportunities for economic growth and development.

Two data collection tasks were performed:

- a) Diesel-fueled vehicle emissions control technologies (ECT) were inspected and overall safety inspections were conducted; all data were recorded.
- b) Exhaust smoke opacity from a randomly elected sample of Addis Ababa’s diesel-fueled vehicle fleet was measured and data recorded.

The sample consisted of four hundred and thirty-six (436) diesel-fueled vehicles tested at twenty-one different roadside test locations in Addis Ababa from October to December 2014. The median age of the sampled vehicles was 12 years. Minibuses (MB) and the Sport Utility Vehicles (SUV) were observed as the dominant diesel-fueled vehicles in the fleet.

Because there is no set test procedure and also “Pass” determination limit for diesel vehicles in Ethiopia, the “pass” limit for this study was borrowed from USEPA recommendation and is set at a smoke opacity value of 40% (USEPA recommended value) (U.S.EPA, November 1998). The reason for borrowing the USEPA recommended value is that it is developed to evaluate the operating conditions of diesel engine mechanical systems and their fuel efficiency. Overall, the opacity fail rate for the sample was 76%, representing vehicles that tested above the 40% limit. About 50% of the sampled diesel-fueled vehicles discharged opacity values between 80% and 100%. These findings suggest that most of the city’s diesel-fueled vehicles are operating with improperly functioning engines.

In addition, few of the diesel-fueled vehicles in the sample has basic ECT. Even the latest model-year diesel-fueled vehicles do not have ECT, however, it is standard equipment for vehicles manufactured and sold in western countries (such as USA and Europe).