



An assessment of gasoline motorcycle emissions performance and understanding their contribution to Tehran air pollution



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ABSTRACT

Motorcycles are the third most common means of transportation in the megacity of Tehran. Hence, measurements of emission factors are essential for Tehran motorcycle fleets. In this study, 60 carburetor motorcycles of various mileages and engine displacement volumes were tested in a chassis dynamometer laboratory according to cold start Euro-3 emissions certification test procedures. For almost all of the tested samples, the average carbon monoxide (CO) emission factors were about seven times higher than the limits for Euro-3 certification. No motorcycle fell within the Euro-3 certification limit on CO emissions. 125 cc engine displacement volume motorcycles, which are dominant in Tehran, have the most total unburned hydrocarbons and CO emission rates, and they have less nitrous oxides (NO_x) emission rates and fuel consumption compared to those of larger engine volume motorcycles. Calculation of fuel-based emission factors and moles of combustion products shows that about 40% of fuel consumed by 125 cc engine volume motorcycles burns to incomplete combustion products. This proportion is lower for larger engine volume motorcycles. Approximation of relative air–fuel ratio results shows very rich combustion in selected motorcycles. Using a carburetor fuel supply system, low engine compression ratio, aging, and no catalyst could be reasons for high emission rates. These reasons could possibly result in high ultrafine particles emission rates from motorcycles. Comparison of total motorcycle pollutant emissions to that of passenger cars from previous studies in Tehran shows that motorcycles contribute to pollutant much higher than their contribution to the total fleet or total travels.

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Introduction

Tehran is one of the world largest metropolitan areas. Like many other megacities, Tehran has serious air quality problems. Every year, more than 40% of the days of the year have been marked as unhealthy and unhealthy for sensitive groups. There has been incidents of city-wide shut-down due to episodes of air pollution during winter. Tehran emissions inventory in the base year of 2014 showed a large contribution of mobile sources to total emissions. Mobile emissions sources in the city of Tehran include more than 3.5 million light duty gasoline vehicles, more than 100 thousands diesel heavy-duty vehicles, and more than 1 million gasoline 4-stroke motorcycles. Motorcycles are used in the city of Tehran for both personal transportation and small parcel deliveries. Limited public transit options and traffic restrictions for vehicles at the city center have encouraged use of motorcycles in recent years. In October 2002, the Iranian government legislated ECE-R40.01 as the

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first national emissions standard for motorcycles. The standard became implemented in 2004 and remained in place afterward. Since 2013, the production or import of motorcycles is allowed only within a minimum emissions standards level equivalent to the Euro-3 emission standard.

As motorcycles are used in Iran as mean of transportation rather than leisure, the situation is similar to that of Southeast Asian countries. In Southeast Asia, motorcycles are one of the main means of transportation. For instance, in many Asian countries, including China, India, Indonesia, Taiwan, Vietnam, and Thailand, the proportion of motorcycles is 60–75% among all on-road vehicles (Schipper et al., 2008; Tsai et al., 2000; Chan et al., 1995). Several studies examined motorcycles emissions in Southeast Asia and in Europe. These studies included measurements of emission factors and volatile organic compounds (VOCs) composition (Costagliola et al., 2014; Chen et al., 2003; Chiang et al., 2014). The effects of mileage, maintenance, catalyst installation, and fuel injection system usage on motorcycles emissions were also studied (Alvarez et al., 2008; Tsai et al., 2000; Yao et al., 2009) and comparisons were made between emissions and performance of motorcycles and passenger cars (Chan et al., 1995; Vasic and Weilenmann, 2006; Costagliola et al., 2014). Moreover, an emissions inventory was developed for estimation of motorcycle air pollution emissions in Vietnam, based on the emissions factors that had been developed for motorcycles with a European driving cycle (Tung et al., 2011). In Europe, one of the working packages of the assessment and reliability of transport emission models and inventory systems project was dedicated to two-wheel vehicle emissions (Boulter, 2007).

Previous studies by Tehran AQCC¹ show that despite small engine volume and low fuel consumption, motorcycles could potentially be major contributors to VOCs, HC, CO, and UFPs. The contribution to total emissions is even stronger in places like Tehran. No study has been done before to quantify motorcycle emission rates and their contribution to total emissions. These are essential data for further studies, such as emission inventories and photochemical pollution distribution models that can be used not only in Tehran, but also in the region. The motorcycle contributions to emissions are high enough that neglecting them produces large errors. Furthermore, measures to mitigate air pollution require accurate motorcycle emissions information to calculate external cost. The current paper summarizes test results and conclusions of the measurements of emission factors of Tehran gasoline motorcycle fleet.

Materials and methods

Method of measurement

There are various methods for the measurement of tail pipe emission in vehicles. More popular techniques are the use of chassis dynamometers with a standard driving cycle and the use of on-board portable emission measurement systems in real-world driving conditions. In the portable emission measurement method, pollutant emissions are measured under real-world driving behavior. Emission factors derived from portable emissions measurement systems are more suitable for use in emissions inventories. The chassis dynamometer method is used in type-approval tests. In the chassis dynamometer method, environmental conditions are controlled. Higher repeatability and accuracy of results is one of the advantages of this method. In order to test a vehicle on a chassis dynamometer, a defined driving cycle is needed. A driving cycle is the pattern of speed versus time which represents the most probable driving conditions of a vehicle in certain environments, such as urban roads or highways (Franco et al., 2013; Frey et al., 2003). Even if real-world driving cycles are used in chassis dynamometer tests, portable emission measurement results are more appropriate for developing real-world emission factors (May et al., 2014; Tong et al., 2000). Nevertheless, in the case of motorcycles, chassis dynamometer tests are the most practical and easy-to-conduct way to develop emissions factors. This is because portable emissions measurement tests require a minimum amount of space and cannot be carried safely by motorcycles. In addition, the weight of portable emission measurement devices is considerable compared to that of the motorcycle. As such, in order to obtain the first data of motorcycle emissions, a standard chassis dynamometer laboratory was used.

Tehran motorcycles driving behavior

Using a GPS tracking method, real-world driving cycle data were collected for a few motorcycles that were used for delivery services. The share of such motorcycles in the total fleet is not known. However, their contribution to the total emission is large as vehicle kilometers traveled is quite considerable compared to those of personal use. While the mileage is generally much higher, the driving behavior is similar to those of personal use. The study was conducted under the assumption of similarity of driving cycles between the two groups. Fig. 1 shows the average speed and the average positive acceleration of motorcycles speed profiles on highways and urban streets in the city of Tehran, compared with those of ECE driving cycles. These measurements were made despite the fact that the operation of motorcycles on highways is prohibited by law, as this law is not enforced. Further, as motorcycles normally do not follow the flow of traffic, their pattern of driving is different than that of other vehicles, even in congested arterial streets.

¹ Air Quality Control Company, a subsidiary of Tehran Municipality responsible for air quality monitoring.

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