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Development of reduction scenarios for criteria air pollutants emission in Tehran Traffic Sector, Iran

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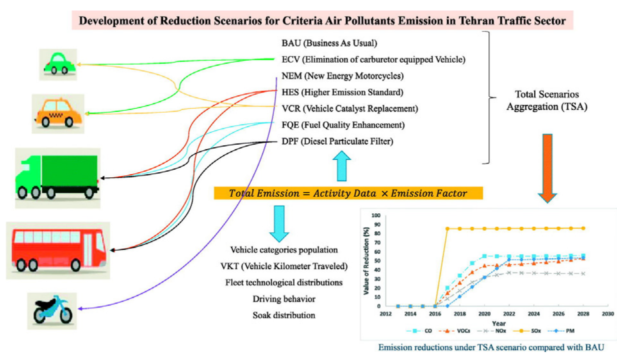
HIGHLIGHTS

- Transport-related pollution as the main source of air pollution must be reduced in Tehran.
- The ECV, VCR, and FQE scenarios provided high performance in CO, VOCs, and NOx emissions control in TMC during 2017–2028.
- The FQE scenario has also an excellent effect on SOx emission reduction (86%).
- The DPF and HES scenarios have the best effect on PM emission reduction (DPF: 51% and HES: 27%) respectively.
- The DPF scenario increases 12% SOx emission in long-term (2028).

GRAPHICAL ABSTRACT



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ABSTRACT

Transport-related pollution as the main source of air pollution must be reduced in Tehran mega-city. The performance of various developed scenarios including BAU (Business As Usual) as baseline scenario, ECV (Elimination of carburetor equipped Vehicle), NEM (New Energy Motorcycles), HES (Higher Emission Standard), VCR (Vehicle Catalyst Replacement), FQE (Fuel Quality Enhancement), DPF (Diesel Particulate Filter) and TSA (Total Scenarios Aggregation) are evaluated by International Vehicle Model up to 2028. In the short term, the ECV, VCR, and FQE scenarios provided high performance in CO, VOCs and NOx emissions control. Also FQE has an excellent effect on SOx emission reduction (86%) and DPF on PM emissions (20%). In the mid-term, the VCR, ECV, and FQE scenarios were presented desirable mean emission reduction on CO, VOCs, and NOx. Moreover, NOx emission reduction of DPF scenario is the most common (14%). Again FQE scenario proves to have great effect on SOx emission reduction in mid-term (86%), DPF and HES scenarios on PM (DPF: 49% and HES: 17%). Finally for the long term, VCR, ECV, FQE, and NEM scenarios were shown good performance in emission control on CO, VOCs and NOx. For SOx only FQE has a good effect in all time periods (FQE: 86%) and DPF and HES scenarios have the best effect on PM emission reduction respectively (DPF: 51% and HES: 27%) compared with BAU scenario. However, DPF scenario increases 12% SOx emission in long-term (2028). It can be generally concluded that VCR and ECV scenarios would achieve a significant reduction on gaseous pollutants emission except for SOx in general and FQE scenarios have desirable performance for all gaseous pollutants in the short term and also for SOx and VOCs in long term. In addition, the DPF and HES would be desirable scenario for emission control on PM in Tehran Traffic Sector.

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1. Introduction

Air pollution has been identified as one of the major environmental hazards for Tehran mega-city (TMC) (Khalilzadeh et al., 2009; Naddafi et al., 2012). This environmental hazard is considered to be formed due to high level of population growth, improper land-use and land-covering changes, ineffective urban policies and measures, as well as, local climatological condition with poor ventilation conditions. First step in air pollution mitigation policies, is the source of emission identification. Based on the findings, the contribution of traffic sources in air pollution emission is estimated to be as much as 85% of all emission in TMC (Shahbazi et al., 2015), which rapid growth rate of vehicle numbers (14.6% annually) worsen this problem (Shahbazi et al., 2016a). Several studies have indicated that the low air quality in cities is often due to emission from mobile sources (e.g. Alonso et al., 2010; Guo et al., 2007; Kara et al., 2014).

Fabricating efficient and operational policies for prevention, reduction and surveillance of atmospheric pollution is very essential at the national and local level. Several cities such as Los Angeles, Mexico City, London and Singapore have much improved air quality despite ever increasing population, increasing vehicle, and kilometers traveled (e.g. Font and Fuller, 2016; Lee et al., 2014; Parrish et al., 2011).

On the basis of the above mentioned facts, research and study on the development of sufficient reduction scenarios for traffic emission will get top priority in air pollution mitigation over TMC region. The quantitative performance of all kinds of vehicular emission control scenarios and their interactions should be analyzed for sufficient decision and policy making in respected region.

Several studies in different scales, global, regional, and local have been conducted for analysis of different vehicular emission control strategies around the world. Cofala et al., analyzed of two scenario CLE (current legislation) and MFR (maximum feasible reductions) on the global scale until 2030 (Cofala et al., 2007). Palencia et al. investigated the effect of zero emission vehicles and lightweight materials on CO_2 emission reduction investigation on Columbian passenger car fleet between 2010 and 2050 (Palencia et al., 2012). Also in one study in China, the effect of changes in vehicles emission between 2000 and 2020 under two scenarios evaluated: 1) NoPol (No-Policy) which emission factors remain the same as they were in 2000 and 2) Euro III standard for all vehicles (except motorcycles and rural vehicles) (Saikawa et al., 2011). Guo et al. studied the amount of vehicular emission reduction under ESU (Emission Standards Updating), HVE (Higher Emission Vehicles Elimination), NEP (New Energy Vehicles Promotion), LPR (LDV population regulation) and IS (integrated) scenarios in comparison with baseline (BAU) scenario in the Beijing-Tianjin-Hebei (BTH) region during 2011–2020 (Guo et al., 2016). Xing et al. researched on future anthropogenic emission in China under REF [0] (current control legislations and implementation status), PC [0] (improvement of energy efficiencies and current environmental legislation), PC [1] (improvement of energy efficiencies and better implementation of environmental legislation), and PC [2] (improvement of energy efficiencies and strict environmental legislation) during 2005 and 2020 (Xing et al., 2011). Zhang et al. examined the past trends of on-road vehicular emission in Beijing and assessed most stringent vehicular control policies on future vehicular emission under Clean Air Action Plan of china until 2020 (Zhang et al., 2014).

Based on the results of the above mentioned studies and that of the others, high efficiency of policies intended to meet control traffic emission can be found in terms of key components of Tehran vehicular emission control such as improving performance of urban public transportation, reduction of urban traffic congestion, higher emission standard, fuel quality enhancement, elimination of carburetor equipped vehicles, new energy cars and motorcycles, vehicle catalyst replacement, utilization of diesel particulate filter and etc.

Our study has focused on the strategies development and their effectiveness analysis for the criteria of air pollutants emission reduction in Tehran Traffic Sector.

2. Material and methods

2.1. Overview of the study area

Tehran, capital of Iran with its 800 km^2 area in 2006 (Alizadeh-Choobari et al., 2016b) and mean average of 1300 m elevation from the sea level sits there from south to north (Jokar Arsanjani, 2012) and has >8.2 million inhabitants, which reaches 12 million with all its counties (Statistical Center of Iran, 2012). Tehran is the most densely populated city of Iran, the 2nd-most crowded city in Western Asia, and the 3rd largest metropolitan area in the Middle-East. >4.2 millions vehicle traveled in Tehran. The high percentage of private cars (72%) and motorcycles (18%) from total registered vehicles seems remarkable (Shahbazi et al., 2016a). Its climate is semi-arid with annual average rainfall of near 268 mm/year (Pahl-Weber et al., 2013) and annual average temperature of about 17.4 °C (Alizadeh-Choobari et al., 2016b) with its minimum temperature in January (nearly 4 °C) and maximum in July (nearly 32 °C) (Crosbie et al., 2014). The urban heat island (UHI) is very noticeable in TMC, where the urban area is up to 6 °C warmer than the surrounding areas (Sodoudi et al., 2014). TMC's UHI has been generated mainly by high level of anthropogenic heat flux from traffic and buildings (Malakooti and Bidokhti, 2014).

Fig. 1 shows the geographical placement of Tehran which is surrounded from north and northeast by Alborz Mountains. This complex topographical condition worsens its air pollution problem among other factors such as population growth, rapid increase in vehicle ownership, high vehicle fleet age distribution and the like (Soltanzadeh et al., 2011; Delkash and Mir, 2016). Air pollution surpass from its national permissible limit is a major problem in Tehran. Based on Air Quality Control Center (AQCC), air quality in Tehran was unhealthy for 111 days in 2015 (Ahadi et al., 2016).

In order to improve the air quality condition, Iran's Environmental Protection Organization (IEPO) has been established and implemented national vehicular emission standards based on Euro standards to control vehicular emission of new vehicles.

Moreover, to decrease the level of mobile emission in Tehran, various regulations such as Traffic restriction in Tehran downtown and odd-even Traffic restriction policy in extended area of Tehran metropolitan center has been manipulated. These traffic limitation policies are deemed necessary in downtown traffic control, while their roles in overall emission reduction have not been found significant (Shahbazi and Hosseini, 2015).

Despite implementation of these policies, condition of air pollutants emission is on the rise and TMC is characterized by high levels of gaseous pollutants and particulate matter, as a serious environmental hazard for human health, ecosystems, and other natural resources (Alizadeh-Choobari et al., 2016a). Therefore, it seems essential to adopt effective policies to prevent the increase and even reduce air pollution emissions.

2.2. Base year Tehran on-road emission database

An emission inventory is a database that lists all resources with their possible contribution in the air pollutants emission in a given time period of activity (EPA, 2012). Many countries and mega-cities have their special emission inventories prepared with various spatial scales and different kinds of air pollutants and greenhouse gaseous (Hogrefe et al., 2003; Kara et al., 2014; Kim et al., 2008). Due to significant changes in amount of air pollutants emissions from different sources with time, it is necessary to update the emission inventories every given period.