AN ASSESSMENT OF THE MOBILE EMISSIONS ON THE TOLL PLAZA OF THE BOSPHORUS BRIDGE OF ISTANBUL, TURKEY

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ABSTRACT

Electronic toll collection system enables bridge, tunnel and turnpike operators to reduce both delays in traffic and air pollution levels. In recent years, motor vehicle emissions tend to be a significant source of air pollution in Istanbul. Istanbul is located at the meeting point of Europe and Asia continents. The city is connected by the two bridges over the Bosphorus (Bosphorus Bridge and Fatih Sultan Mehmet (FSM) Bridge). The Bosphorus Bridge carries the heaviest vehicular volumes of the bridges due to its location in the city center. The number of the car in the city is exceeded 1.7 million. About 80% of the vehicles use the Bosphorus Bridge is the car. The electronic toll collection deployment (locally called OGS system) which began in 1999 has already enjoyed a significant market penetration. Currently, 4 of the 15 toll lanes at the foot of Asian side of the Bosphorus Bridge toll plaza are used for electronic toll collection.
In this study, in order to make an assessment the anticipated impact of OGS on the air quality at the toll plaza the emissions of CO, NOx and were estimated HCs using MOBILE 6 Mobile Source Emission Factor Model of EPA. Furthermore, total emissions were compared for manned tollbooths and OGS lanes.

INTRODUCTION

In urban areas, bridges are important connection elements in daily traffic as well as divided cities by the water channels and rivers. The use of electronic toll collection is an effective strategy for mitigating air quality related problems and reducing delay on the bridges. Generally, during rush-hour periods, most of the delay experienced at the toll facility is from time spent in queues. There are several studies in assessments of air quality problems and traffic for toll plaza areas. Recently, Mark [1] analyzed the potential air quality benefits replacing traditional toll collection with electronic toll collection system. It may also have significant economic value in terms of pollution reduction. Al-Deek et al., [2,3] also summarized the improvements in traffic operations at electronic toll collection plazas as well as service time per vehicle. Furthermore, Levinson and Chang [4] developed a model to maximize social welfare associated with a toll plaza.

Istanbul is one of the mega cities in the world. About 40 percent of the city is living lives in Asian part of the city and the most part of the business centers are in the European side. The city is connected by the two bridges. These are Bosphorus and Fatih Sultan Mehmet Bridges. The Bosphorus Bridge carries the heaviest vehicular volumes of the bridges due to its location

in the city center. In order to prevent the delaying of the bridge traffic and reducing air pollution during rush hour periods electronic toll collection (locally called OGS system) OGS deployment was began in 1999 at the foot of Asian side of the Bosphorus Bridge. Currently, 4 of the 15 tollbooths at the foot of Asian side of the Bosphorus Bridge toll plaza are used for electronic toll collection.

It is known that the adverse effect of toll plaza is particularly evident during rush hours, when traffic is usually heavy. However, the potential impact on mobile emissions from the use of OGS system has not been extensively investigated for the both bridges.

The goal of the study is to estimate the air pollution potential over the bridge and toll plaza location. MOBILE 6, a mobile emissions modeling software was used to analyze and make an assessment the anticipated impact of OGS on the air quality at the toll plaza. For this purpose, we have estimated the emissions of CO, NOx and HCs using MOBILE 6 Mobile Source Emission Factor Model of EPA.

TRAFFIC OVER THE BOSPHORUS BRIDGE

Urban air quality is mostly dominated by traffic emissions in most of the cities. Mobile sources are used to describe a wide variety of vehicles, engines and equipment that generate air pollution. Mobile sources pollute the atmosphere through combustion and fuel evaporation. These emissions contribute greatly to air pollution and are the primary cause of air pollution in urban areas. Road transport emissions were mostly responsible for CO, NOx, HCs and CO emissions. These pollutants affect vegetation, human health via the blood and respiratory systems, and increase global warming. The emissions are characterized by large number of sources with low source heights. It is known that the primary source of many urban air pollutants of health concern is vehicular traffic. Dispersion of these pollutants from the car exhaust can affect the emissions in the environment. Due to the automotive engines are major sources of fine particles, fine and ultrafine particles have recently become of great interest due to their adverse health effects.

Istanbul is one of the mega cities in the world with a population of about 12 million inhabitants. Bosphorus separates the city as Europe and Asia. About 40 percent of the city is living lives in Asian part of the city and the most part of the business centers are in the European side. The city is connected by the two bridges. The Bosphorus Bridge which is about 1500 meter long carries the heaviest vehicular volumes of the bridges due to its location in the city.
According to Highway report 5] the number of car passing over the Bosphorus Bridge is 1.945.650 in July 2002 and 1.766.995 in January 2003. About 80% of the vehicles passing over the Bosphorus Bridge are the cars. Approximately 70,000 car use Bosphorus Bridge every day. 98% of the total car use gasoline and the other is diesel.
Besides, the observed mean service time at the manned tollbooths during the rush-hours varied in between 10-60 seconds according to positioning of lanes was Bosphorus Bridge toll plaza.

MODEL APPLICATION

In this study, in order to estimate the emissions of CO, NOx and HCs over the Bosphorus Bridge at the Asian foot and to make an assessment the anticipated impact of OGS on the air

quality at the toll plaza, MOBILE 6 Mobile Source Emission Factor Model of EPA was used for two representative months in summer and winter season. This model is the latest update to a new understanding of vehicle emission processes. MOBILE 6 has been explained in EPA [6]. The model calculates emissions of volatile organic compounds (VOCs), nitrogen oxides (NO_X) and carbon monoxide (CO) from passenger cars, motorcycles, buses, and light-duty and heavy-duty trucks. The model accounts for the emission impacts of factors such as changes in vehicle emission standards, changes in vehicle populations and activity, and variation in local conditions such as temperature, humidity, fuel quality, and air quality programs. A mobile source emission model produces estimates of emissions under a wide variety of traffic conditions and roadway configurations [6]. These emission estimates are made by two types of inputs as well as emissions rates and travel.

In this study, July 2002 and January 2003 weekday traffic were selected for model application as representative summer and winter months [7]. Furthermore, the two scenarios were analyzed to quantify air quality associated with OGS deployment.
The model can estimate the emissions for 28 vehicle types. In this study, we have used the four type vehicle, as well as gasoline, diesel cars and minibus and motorcycles passing over the bridge. The input data and the local model parameters have been provided by the General Directorate of Highways. The scenarios parameters are given in Table 1 for July 2002 and January 2003 [7]. The parameters given in the table indicate different atmospheric conditions. Furthermore the average speed of the vehicles is assumed as 60 km/hour and the speed of vehicles using the OGS lines is 30 km/h. This value is the maximum limit of the vehicles passing over the OGS lines. Besides, the speed of vehicles which use the manned tollbooths is considered as an average 10 km/h. However, it is known that the Mobile 6 is not the most effective modeling tool at toll facilities, because it does not capture additional impact of frequent stops, and acceleration and decelerations on mobile emission production.

RESULTS

According to EPA, on-road vehicles account for 5% of VOC emissions, 64% of NOx emissions, and 82% of CO emissions. These pollutants can cause adverse health effects such as decreased lung capacity, heart disease, bronchitis, eye irritation. The most of the worse conditions can be occurred when cars accelerate and decelerate. In this study, the total emission factors also are given in Table 2 for both months and for each vehicle types.
In this study, total emissions over the Bosphorus Bridge for considered months are given in Table 3. Total Hydrocarbons, THC, CO and NOx are calculated for both months according to vehicle types. Furthermore, the total values of THC, CO and NOx are estimated for Istanbul. THC, CO and NOx are 103.0 tons/day, 568.0 tons/day and 113.0 tons/day respectively [7].

The two scenarios were applied to quantify air quality associated with OGS deployment. Figures 1, 2 and 3 illustrates the scenarios of THC, CO and NOx for the gasoline and diesel vehicles and for manned and OGS tollbooths. The current deployment level of electronic toll collection system has improved the average travel speed by more than 100 % and has decreased the mobile emissions rate at the toll plaza. The estimated decrease in peak-hour mobile emissions attributed to OGS deployment were 49.0 % decrease in both January and July for HC, with 1.1 kg and 1.4 kg, 48% and 49% decrease for July and January respectively for NOx, with 12.0 kg and 16.0 kg and 48% decrease for both month for CO [7]. Besides THC emissions were found higher for July 2002 than January 2003. Furthermore NOx and CO emissions were higher for January 2003

The results of Technical Report [8] for Baltimore metropolitan area supports Istanbul Bosphorus toll plaza levels. Finally, the use of electronic toll collection is an effective strategy for mitigating air quality related problems. Therefore, it is expected that bridge tolls could improve traffic flow and reduce air pollution.

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Table 1. Scenarios parameters

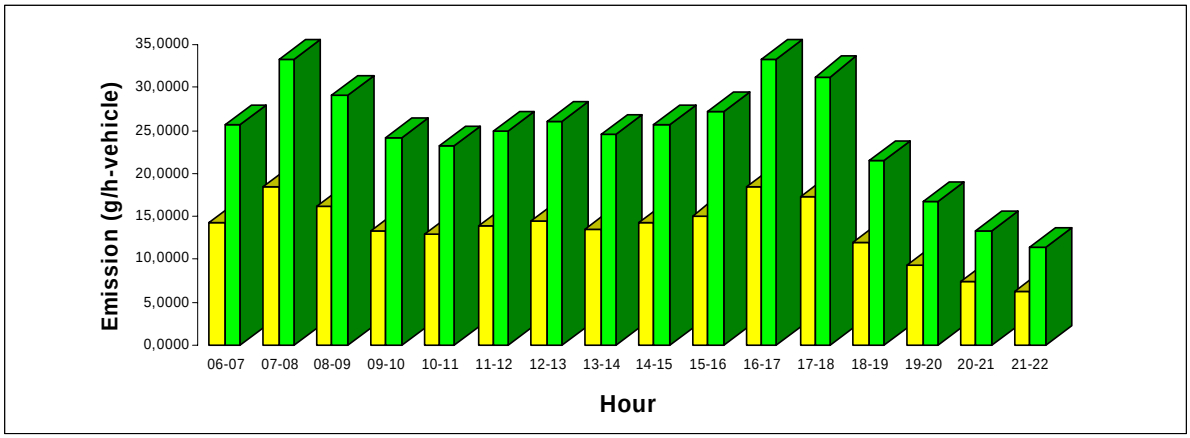
Parameter	Januray 2003	July 2002
Max.temperature (C)	10.2	32.1
Min. temperature(C)	4.9	21.9
Avg.Temp (C)	7.6	27.0
Reid vapor pressure (kPa)	70	60
Absolute humidity (g/kg dry air)	5	15.3
Atmospheric Pressure (atm)	1	1
Relative humidity(%)	79	69
Bridge height (above sea level)	160	160

Table 2. Total emission factors for the vehicles passing over the Bosphorus Bridge (g/km-vehicle)

Pollutant	January 2003				July 2002			
	Gasoline cars	Diesel cars	Minivan diesel vehicles	Motorcycles	Gasoline cars	Diesel cars	Minivan diesel vehicles	Motorcycles
THC	2,71	0,98	0,89	7,23	3,09	1,02	0,99	8,56
CO	42,37	2,25	1,60	25,95	31,79	2,31	1,72	26,58
NOx	2,55	2,02	1,51	3,28	2,02	2,05	1,66	1,99

Table 3 Total emissions (tons/day) over Bosphorus Bridge for July 2002 and January 2003

Vehicle type	January 2003 (tons/day)			July 2002 (tons/day)		
	THC	CO	NOx	THC	CO	NOx
Gasoline car	0,48	7,54	0,45	0,60	6,23	0,40
Diesel car	0,17	0,40	0,36	0,20	0,45	0,40
Minivan and similar diesel vehicles	0,16	0,29	0,27	0,19	0,34	0,33
Motorcycles	1,29	4,61	0,58	1,68	5,21	0,39
Total	2.10	12.83	1.67	2.67	12.22	1.51



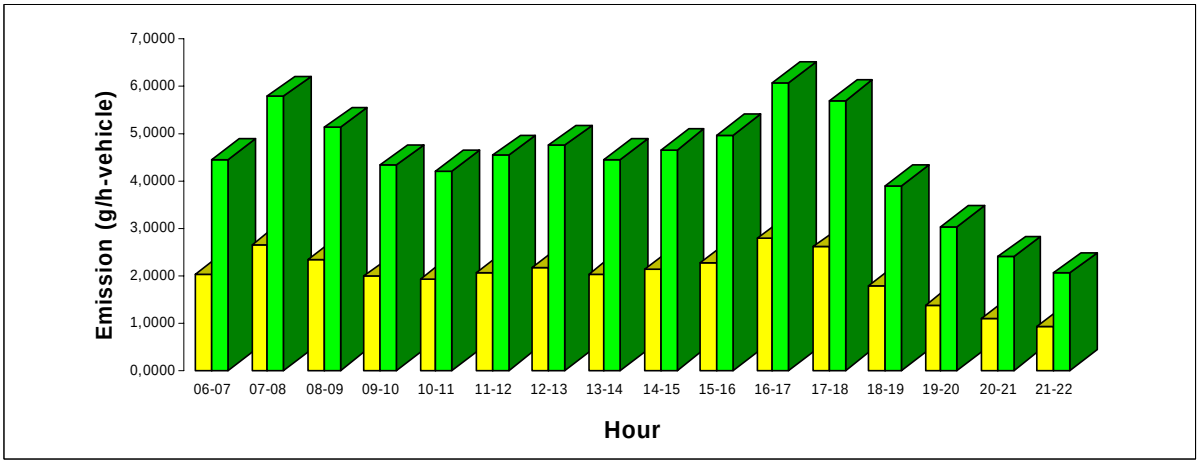


Fig.1. CO emissions of gasoline (above) and diesel (below) cars for manned (green) and OGS (yellow) tollbooths for winter.

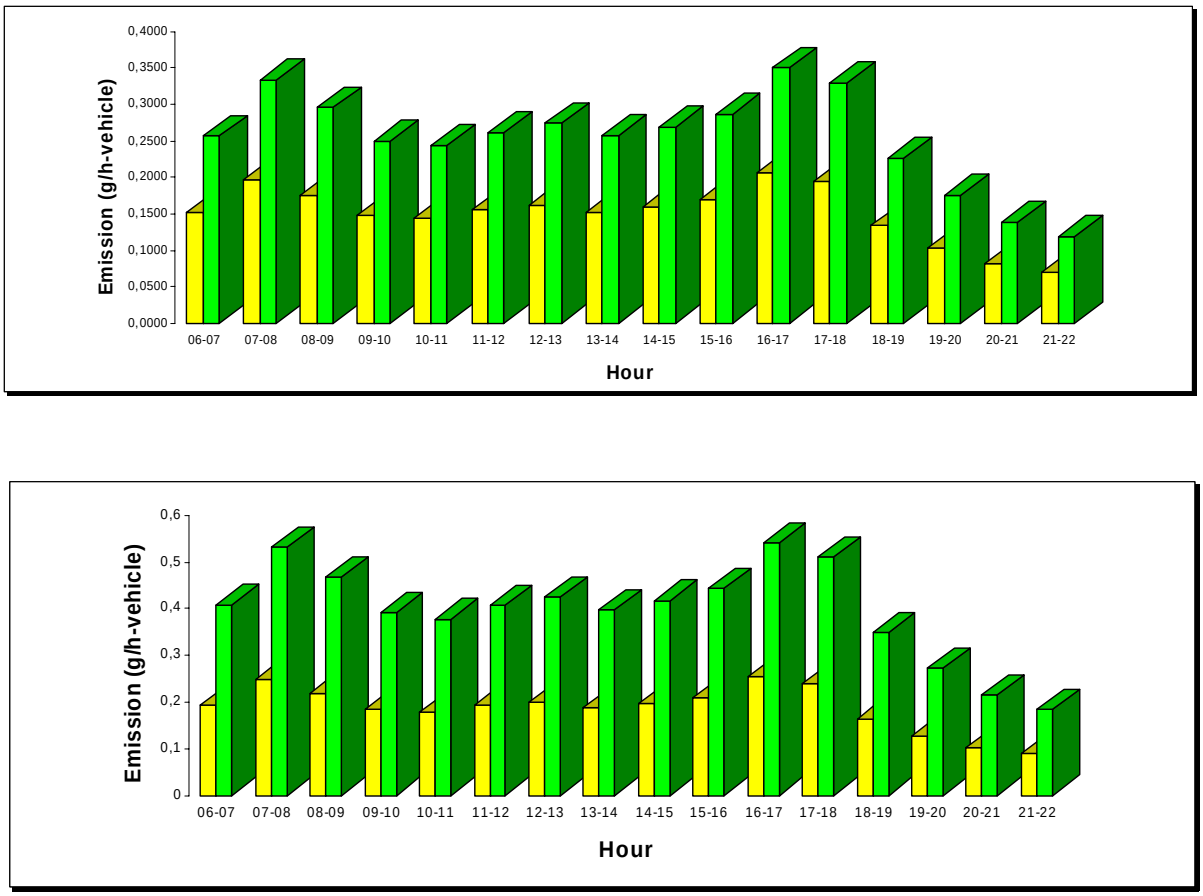


Fig.2 Total Hydrocarbon emissions (THC) of gasoline and diesel cars for manned and OGS tollbooths.

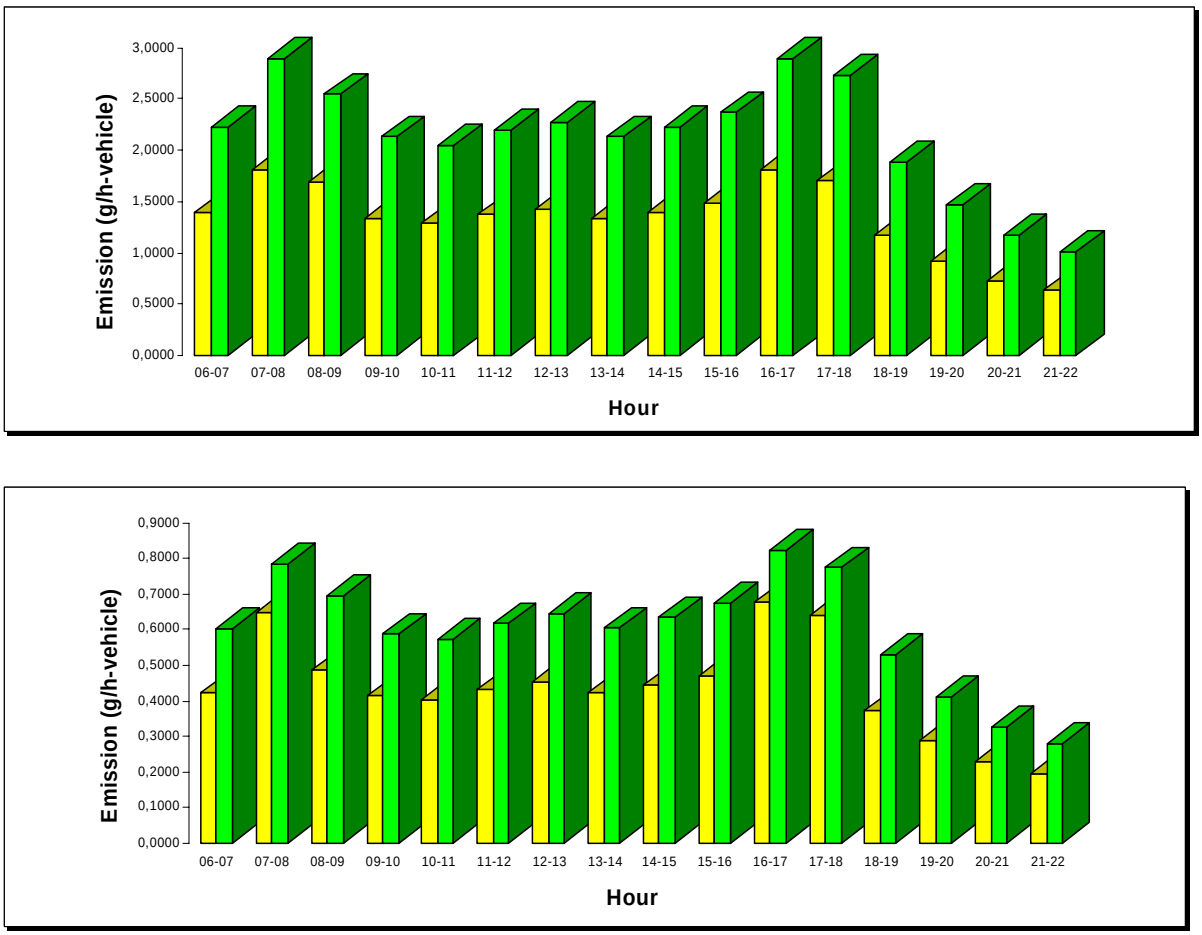


Fig.3 NOx emissions of gasoline and diesel cars for manned and OGS tollbooths.