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Research Article

How Motor Vehicles Affect Air Pollution in Erzurum Centre?

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Keywords

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Exhaust emissions,
CO,
HC,
Statistical analyze.

Abstract

When pollutants in air are high in concentration and in duration air pollution occurs so as to give harm to human beings, animals and plants. The main reason of air pollution is human activities; especially motor vehicles are accepted as the main source of air pollution. The comfort that the technology provides the people makes the motor vehicles an indispensable part of our life, so the number of motor vehicles is increasing day by day. With the increase of vehicles in number, vehicle queues occur on the ways, especially on the signalized junctions. Because of the geographical position of Erzurum, the winters are cold and last long. Also because of the high altitude, in winters the average heat is low and besides that the percentage of O2 falls to 16,5. This causes incomplete combustion both in the stationary combustion processes and in the motor engines. As a result of this the amount of the pollutants like HC and CO is increasing. In this study, the effects of the geographical position and the meteorological peculiarities of Erzurum on the pollutants emitted by motor vehicles are examined. For this the exhaust gaseous emission measurements of 30370 motor vehicles made in various months are inspected statistically. The main result of these statistical analyses is that the pollutants like CO and HC are raising the maximum concentration in the older model vehicles. The main reason of this is the converter usage in the newer model vehicles.

1. Introduction

All over the world air pollution is increasing day by day and affecting us and our environment. The duration of air pollution and its independence on the seasonal conditions show that exhaust emissions of motor vehicles are the main reason of air pollution in the urban environment [1]. Research has shown that certain air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) or particulate matter (PM) have adverse effects on health. The World Health Organization has declared air pollution a threat to public health and a major environmental health problem [2].

Nowadays, the increase of population in crowded cities brings up the increase in the number of motor vehicles. As a result of this, air pollution becomes a more important problem so that it can be seen by naked eyes.

Vehicle fuel consumption and engine emissions are two critical aspects that are considered in the transportation planning of highway facilities. Transportation is one of the major contributors to man-made polluting emissions. Although emissions from individual cars are generally low, since the number of motor vehicles in the country becomes greater day and day, the combined emissions and fuel consumption cannot be disregarded. In fact, personal automobiles are the single largest polluters [3].

Most of the emissions are generated in the combustion process and by evaporation of the fuel itself. Gasoline and diesel fuels are comprised of hydrocarbons and compounds of hydrogen and carbon atoms. In a perfect combustion, all the hydrogen in the fuel is converted to water and the carbon-to-carbon dioxide but the perfect combustion process is impossible to achieve in the real world and many pollutants form as byproducts of this incomplete combustion process.

The principal pollutants emitted from typical motor vehicle are carbon monoxide, hydrocarbons and oxides of nitrogen [4-8]. Carbon monoxide (CO), a product of incomplete combustion, is a colorless, odorless and poisonous gas [9]. The motor vehicle contribution to carbon monoxide emissions can exceed 90 percent [10]. Hydrocarbon (HC) emissions result from fuel that does not burn completely in the engine. It reacts with nitrogen oxides to form ozone under catalytic effect of sunlight, which is a major component of smog [6]. Furthermore, hydrocarbons emitted by vehicle exhaust systems are also toxic and are known to cause cancer in the long term [11]. While CO and HC are the products of the incomplete combustion of motor fuels; oxides of nitrogen (NO_x) are formed differently. NO_x is formed during the combustion process at high temperature and pressure while O_2 and H_2 are reacting. NO_x also leads to the formation of acid rain and it is known that NO_x is harmful for human health [4].

The air/fuel ratio (AFR) is one of the most important variables affecting the efficiency of catalytic converters and the level of exhaust emissions [4]. CO emissions from internal combustion engines are controlled primarily by the fuel/air equivalence ratio. For fuel-rich mixtures, CO concentrations in the exhaust increase steadily with increasing equivalence ratio, as the amount of excess fuel increases. For fuel-lean mixtures, CO concentrations in the exhaust vary little with equivalence ratio and are order 10"3 mole fraction. The highest CO and HC levels are produced under fuel-rich conditions, and the highest NO_x level is emitted under fuel-lean conditions. Generally, fuel-rich operations occur during cold-start conditions or under heavy engine loads such as during rapid accelerations at high speeds and on step grades. Therefore, high levels of CO and HC are generated on congested highways and in other high traffic density areas [4,12-13].

Other factors affecting emission rates are travel-related factors, high network characteristics, vehicle characteristics and meteorological conditions. Number of trips, the distance traveled, traffic density, grade on highways, geometric design of the highway, signalized intersections, vehicle age, engine size, emission control systems and also the weather temperature affect the emission rates [3,11,14,15].

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The general trend in combustion engines is the reduction of harmful emissions into the atmosphere. This can be achieved by enhancing the fuel efficiency of combustion engines, i.e., decreasing fuel consumption and harmful emissions accordingly, and by the capture of pollutants from exhaust gases [16].

In this study, to understand the effects of motor vehicles on the air pollution, the pollutants emitted by them are discussed. For this purpose, the exhaust gaseous emission measurements of 30370 motor vehicles, are inspected statistically. By this way, emission amounts in various months and weather conditions were examined according to vehicle ages.

2. Testing process

Erzurum city's longitude is 40°15-42°35'East, latitude 39°10'-40°57' north and lies in the eastern of Turkey. Erzurum, located on a flat plain is surrounded by mountains at all sides and the center of commerce and industry in the Eastern Turkey. Total residential area of Erzurum is 25066 m^2. Erzurum has a climate with cool and dried winters and warm and dried summers. The coldest and wettest months are December and January while the hottest are July and August. The average annual temperature is 6°C. Its altitude is 1860 m. Because of high altitude and air pollution in winter the oxygen percentage falls to 16.4%. The map of Erzurum city is given in Figure 1.

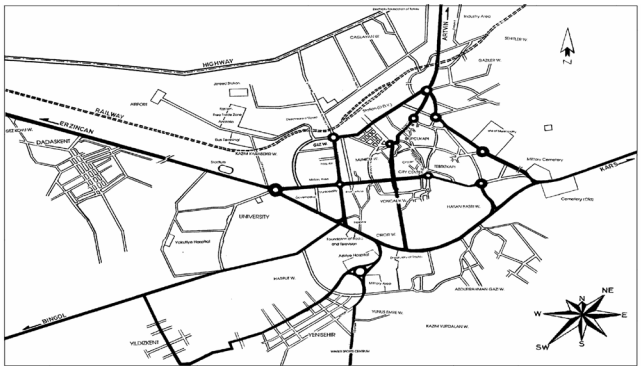

Figure 1. Erzurum city map

The number of motor vehicles in Erzurum is increasing day by day. The measurements show that this number affects the air pollution in the city center, especially in signalized junctions. In Erzurum in winters the amount of oxygen is very low (16.4 %) as a result of this motor vehicles show 20% more incomplete combustion when compared with the see level [17]. Especially in winter months, because of the high decrease in temperature, cold-start of fuel motor vehicles causes incomplete combustion and increases air pollutants.

As a result, the air pollution emitted from motor vehicles is increasing day by day in Erzurum, because the increase in the number of motor vehicles is lasting. Moreover, alternative energy sources like electric vehicles, are not widespread enough, yet. Thus, some regulations must be done in fuel and diesel oil and in the vehicles.

In this study made for determining the air pollution caused by motor vehicles in Erzurum, the exhaust emission measurements of 30370 motor vehicles, which were taken from Environment, Urbanization and Climate Change Provincial Directorate Erzurum, were entered as data to excel program. After these data consisted of CO, CO_2, HC, O_2 and AFR (Air Fuel Ratio) were given to excel program, they were performed using computer statistical programs.

The values were classified according to the measurement year, month and ages of the vehicles were determined. In this examination variance analysis was made with the measurement values of CO, CO_2, HC, O_2 and AFR and the results were interpreted according to the parameters above. The changes in the amounts of CO and HC for vehicle ages and for measurement month and year were examined.

3. Results

3.1. The change of CO and HC concentrations emitted according to vehicle age

As it can be seen from Figures 2 and 3, CO and also HC concentrations showed significant changes depending on the vehicle age. In new model vehicles, these values were too lower than in the old model vehicles. Older vehicles produce higher emission rates than newer fuel-injected vehicles during normal operation and vehicle starts. Furthermore, older vehicles are not held to the same restrictive vehicle standards as newer vehicles. Without proper vehicle maintenance, fuel consumption can increase by as much as 40 percent.

According to research, improper engine tuning can increase average fuel consumption by about 10 percent and wheel misalignment as small as 2 mm can cause an increase of fuel consumption by about 3 percent due to tire rolling resistance [3]. And also the main reason of this decrease of HC concentration can be explained by the converter usage especially in recent years. Especially after 1990's these values indicated very important decreases. For determining the effect of vehicle age on CO and HC concentration only a vehicle mark group was chosen and different age cars of this group were examined as shown in Figure 4.

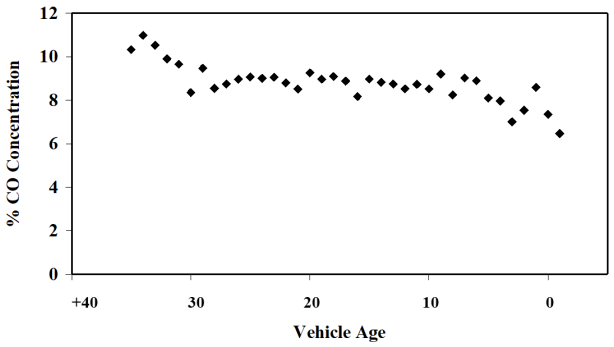

Figure 2. The change of CO emitted according to age

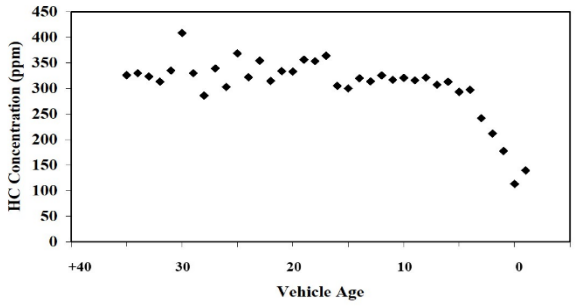

Figure 3. The change of HC emitted according to vehicle age

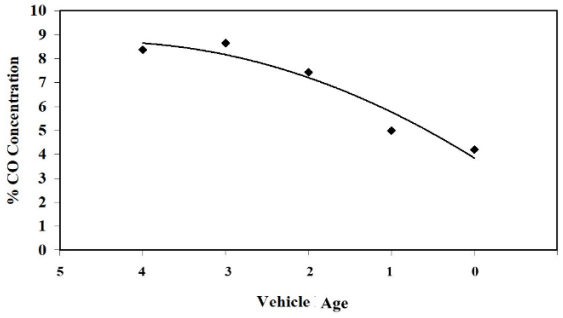

Figure 4. CO emission change for vehicles of the same brand

3.2. The change of CO and HC concentrations emitted according to converter existence

It was observed that the converters decrease HC and also CO concentrations evidently. It can be seen from the Figures 5 and 6 that especially HC concentration was very low in vehicles with converter.

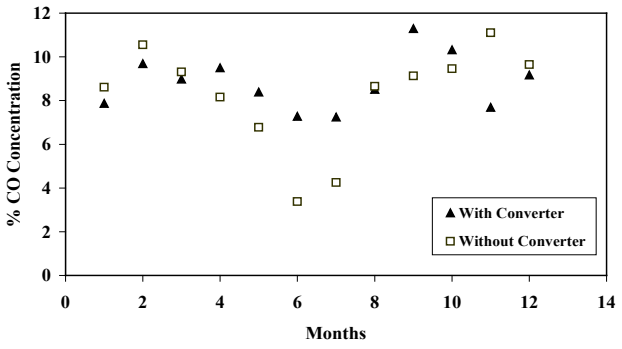

Figure 5. The change of CO emitted according to converter existence

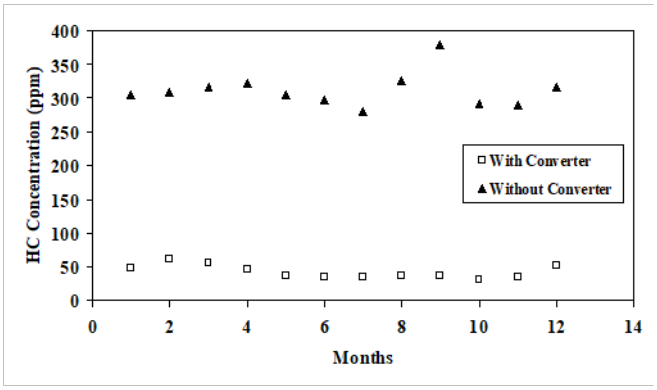

Figure 6. The change of HC emitted according to converter existence

The difference in the number of the vehicles with converter and the vehicles without converter was too much. Because of this reason the effects of converters on CO concentration could not be seen clearly. The number of vehicles with converter were 3293 while the number of vehicles free converter were 27077. Converter was effective especially in winter months. In winter the CO concentration was lower than in summer months. But according to statistical results this equilibrium was change in summer months.

3.3. The change of CO and HC concentrations emitted according to fuel type

Especially HC and CO concentrations of the vehicles run with gasoline or diesel oil shown differences statistically. 29640 of the cars run with gasoline were measured but only 730 of those run with diesel oil. Because of the great difference between the number of these groups sufficient results could not be taken from the analyzes. The vehicles with gasoline emitted more HC than the vehicles with diesel oil.

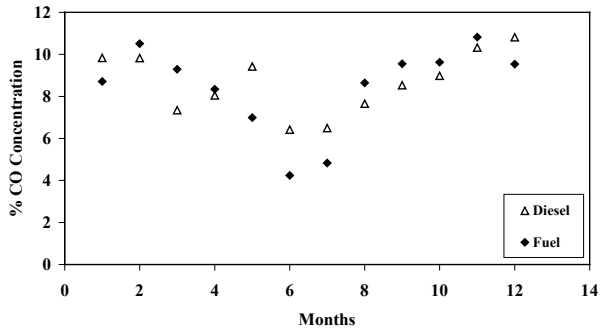

Figure 7. The change of CO emitted according to fuel type

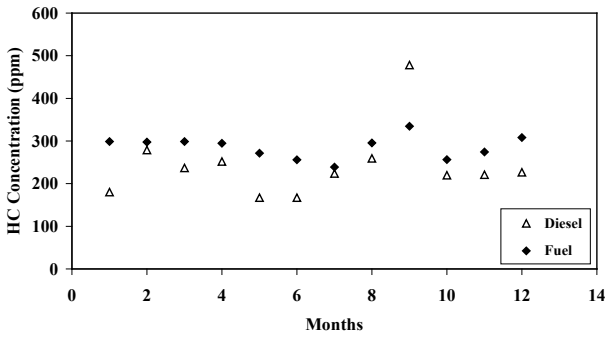

Figure 8. The change of HC emitted according to fuel type

3.4. The change of CO and HC concentrations emitted according to months

It is determined that CO and HC concentrations showed differences depending on the measurement months. Especially in winter months like December, January and February these values were too high however the pollutant concentrations decreased in June and July. This case could be explained with incomplete combustion in winter months. Figures 9-10 show the change of CO and HC according to months, respectively.

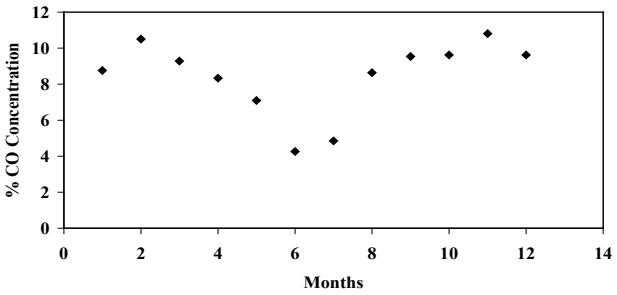

Figure 9. The change of CO emitted according to months

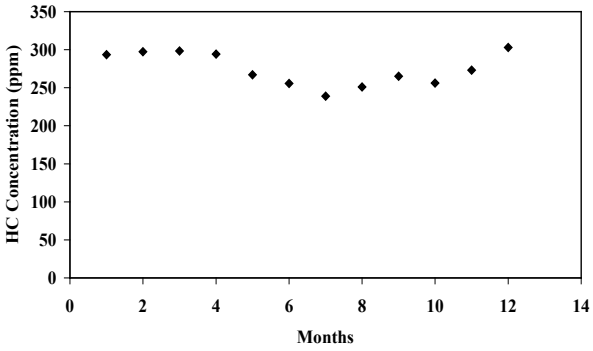

Figure 10. The change of HC emitted according to months

4. Conclusions

As a result of this study, it is observed that the converter decreases the pollution significantly and also pollutant emissions amount depends on the vehicle age seriously. Because of this, old model cars should be maintained regularly for preventing pollution. And it is clearly seen that emission amounts are directly related to air temperature. The decrease in air temperature increases the pollutant amounts.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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