CARBON MONOXIDE EXPOSURE IN KERMANSHAH CITIZENS, IRAN

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ABSTRACT
This study was conducted to determine citizens exposure with carbon monoxide in Kermanshah city, Iran. Total numbers of 2240 samples were measured at stationary and non-stationary stations, equally. Stationary stations included 5 at city center residential area, 5 at less traffic area, 5 at commercial area, 3 and 2 stations at commercial-industrial and industrial areas respectively. Non-stationary measurements have been made inside the taxis cabins. All measurements were conducted seasonally at the middle of each season for a full week in the morning and afternoon. The averages of CO concentrations for both morning and afternoon measurements in the year at city center residential, less traffic area, commercial, commercial-industrial and industrial area were 4.7, 1.6, 13.3, 6.2, 4.4 ppm, respectively and It was 38.4 ppm in taxis cabins. The highest averages of CO concentrations in stationary stations at the mornings and afternoons were observed in commercial stations with 9.6 and 17 ppm respectively. Also, the seasonally averages of CO concentrations were 6.1, 5.3, 6.6 and 6.8 ppm at stationary stations in spring, summer, autumn, and winter, respectively. Direct relationship between automobile speed and CO concentration especially in sudden braking with peak level of CO concentration of 85 ppm was observed.

INTRODUCTION
Carbon monoxide (CO) is colorless, odorless and tasteless poisonous gas. It is a byproduct of incomplete burning of fuels. Industrial processes contribute to carbon monoxide pollution levels, but the principal source of CO in most large urban areas is vehicle emission. Form the late 1960s through the early 1980s; CO was the major air pollutant of concern. It is considered as a dangerous asphyxiant because it combines strongly with hemoglobin and reduces blood's ability to carry oxygen to cell tissues [1]. The adverse health effects associated with CO vary with its concentration and duration of exposure [2, 3]. CO concentration of 10 to 100 ppm in ambient air and inside motor vehicles cabins can exert adverse health effects on the general population [2, 3, 5, 6 and 7]. Because motor vehicles traffic is the major source of CO, daily concentration peaks coincide with morning and evening rush hours. The health threat from CO is most serious for those who suffer from cardiovascular disease. CO emissions are substantially greater in cold weather because cars consume more fuel to starts at cold temperatures and some emission control devices such as oxygen sensors and catalytic converters operate less efficiently when they are cold [2, 3, and 8]. In many American cities, high short-term peak CO concentration (mean value 50 ppm) occurs in heavy traffic areas. Exposure to these ambient CO levels may affect groups of people who work on the streets such as bus and truck drivers, police officers, vehicle inspectors, street repairing workers, street cleaners, street vendors, parking attendants , pedestrians, and cyclists. Vehicles drivers are also exposed to CO from traffic and leakage of their own vehicle's exhaust [8, 9].

U.S. Environmental Protection Agency (EPA) had proposed 9 ppm for 8-hour and 35 ppm for 1-hour protect susceptible population groups from adverse effects resulting from CO exposures in the outdoor environment [4]. CO exposure continues to be a matter of great concern in the world due to its association with high incidence of morbidity and mortality.

MATERIAL AND METHODS

This study was conducted to determine citizen exposure to CO in Kermanshah city, during 2001-2002. Kermanshah is located at 450 Km far away from Tehran in the west of Iran. It is one of the well-known Iranian ancient cities that its civilization culture back to 2000 BC. It had about 65 square Km area, 800000 population and located at 1420 meters above sea level. Mean value of rainfall was approximated 465 mm annually and mean air temperature varies from 14.2-9.2 ^{o}C during spring to the winter. Mean value of atmospheric inversion at autumn and winter were 55% and 70%, respectively. The average of govern wind velocity was about 4 m/s in which 18% came from west and 16% from south east.

Measuring of CO concentrations was carried out at 20 stationary stations and inside the taxis cabins as non–stationary stations. Stationary stations have been selected based on city areas. They included 5 at city center residential area, 5 at less traffic area 2-6 Km away from city center, 5 at commercial area on the pavement, 3 and 2 stations at commercial–industrial and industrial areas, respectively. The taxis which used to transportation of measuring team between two stations were selected as non-stationary stations. They were Peykan brand from different ages and were selected randomly in the street before going to each stationary station.

Air has been monitored by a CO direct-reading meter with a resolution of 0.1 ppm and accuracy of ±1ppm. All measurements were conducted seasonally, spring to winter, at the middle of each season for a full week in the morning, 8-12 AM, and afternoon,15-17pm,. Sampling time at the stationary stations was 5 minutes and inside the taxis cabins based on distance between stationary stations varies from 3-8 minutes. Cigarette smoking was prohibited for both taxis drivers and passengers during measuring time. Total numbers of measurements were 2240 in which 50% at both stationary and non-stationary stations equally.

RESULTS AND DISCUSION

Table 1 shows seasonally averaged and annual mean values with standard deviations of CO concentration at 5 stationary and non-stationary stations. Rapid examination of data in this table indicates high level of CO concentration at non-stationary stations. The commercial area stations also show the higher than 8-hour standard CO concentration. Table 2 contains the results of annually mean values of CO concentration at different stationary stations during whole weekdays. A typical annual result of the mean values of CO concentration during weekdays and different wind speeds is shown in figure 1. It seems that the decreasing in the city transportation in week end, Thursday afternoon and Friday, along with low wind speed were two effective factors to lower concentration of CO in the different areas in Kermanshah city. To show the wind effect on pollutant concentration in the city atmosphere, the annual mean values of CO concentration were plotted versus different wind speeds in figure 2 for all stationary stations. This figure well

shows the effect of wind speeds on decreasing of the CO levels in the atmosphere at all stationary stations absolutely. This effect is not noticeable for wind speed below 1.5 m/s but it strongly is effective to decreases the CO and other pollutants levels in the city atmosphere at speeds upper than 2 m/s.

Figure 3 presents mean value of CO concentration inside the different taxis based on their ages in various seasons. It clearly shows the positive relationship between CO concentration inside the taxi cabin and its age. The percentages of CO concentration that exceeded 8-hour standard (9 ppm) were: 98.1% in non-stationary stations, 71.3% in commercial, 18.2% in commercial-industrial, 8.2% in city center residential, 5.2% in industrial, and 0% in less traffic area stations.

The results showed that the annual mean value of CO concentration for both morning and afternoon measurements at 1120 stationary stations vary from 2.22-13.00 ppm with standard deviation (SD) of 1.43-3.40 for less traffic and commercial areas respectively, whereas those were 39.22 ppm with SD of 5.72 for 1120 measurements in non-stationary stations (see Table 1). Seasonally averaged minimum of CO concentration was seen in less traffic area stations (2.00 ppm with SD=1.18) in summer. The lower traffic and locate far from city center made the sub urban area, less traffic, cleaner than other areas. The lower mean value of CO concentration in the summer might be due to higher wind speeds in this season. The maximum level of CO concentration was observed in winter with mean value of 16.5 ppm and SD of 3.22 at the commercial stations. This might be due to high density traffic in these area and atmospheric inversion at winter.

There were some differences between morning and afternoon mean values. Except for week end, Thursday and Friday, the afternoon mean values in all stationary stations were upper than those for morning (table 2). This might be due to relative accumulation of pollutants in the city atmosphere and rush hour in the afternoon.

Seasonally averaged CO concentrations at all non-stationary stations vary from 37.20 (SD=5.75) in winter to 41.58 ppm (SD=6.97) in spring which are concerning levels. This is a self contamination process in taxis as well as other automobiles. High level of CO in taxi cabin is due to entering exhaust gases from back of vehicle by suction forces created in relative high speeds. Direct relationship between automobile speed and CO concentration especially in sudden braking with peak level of CO concentration of 85 ppm was observed. The other parameter affected on taxi cabin CO level was the taxi age. As figure 3 shows, the older taxis had higher level of CO concentration inside their cabins and there is not any difference among seasons in this regard. It suppose that the observed fluctuations in CO level trends, figure 3, with taxis ages are due to case problems and each year more in taxi age upper than 10, could increase CO level of about 5% inside its cabin. Of course the Peykan brand taxis which are prevalent in Iranian cities and studied in this work, have an old and inefficient technology in fuel burning at all.

Conclusion

The results of this work clearly showed that considerable exposure to high levels of CO concentration are existed in taxis cabins and commercial area that are highly exceeded from recommended standard level (more than 3 times of 8-hour threshold, established by EPA). Also the use of old taxis in the city could expose their drivers and passengers to higher level of CO concentration which cause the adverse effects on them. Based on the figure 3 the optimum age for Peykan brand taxis may be 10 years, because by increasing

the taxi age from 10 to 21 years, CO concentration level inside the taxis cabins go up rapidly at least 50%. Finally, findings of this study clearly showed that the main source of high levels of CO concentrations in Kermanshah as a non-industrialized city is traffic. Hence the main force to decrease the citizens exposure to the CO level must be focused on improving public transportation, traffic and renew the fleet.

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Station Area	Spring		Summer		Fall		Winter		Annual	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
City center residential	4.20	1.31	3.42	1.20	5.39	1.27	5.83	1.41	4.71	1.39
Less traffic	1.42	1.14	1.12	1.18	1.91	1.13	2.11	1.20	1.64	1.43
Commercial	12.83	3.44	11.30	2.33	13.57	3.90	15.5	3.22	13.30	3.40
Commercial-Industrial	6.44	1.63	5.48	1.36	5.93	1.28	6.91	2.57	6.2	1.87
Industrial	4.04	1.65	4.73	1.59	3.98	1.42	4.77	1.76	4.38	1.81
Non-stationary (Taxis cabins)	41.58	6.79	37.47	5.77	37.43	5.19	37.20	5.75	38.42	5.72

Table 1- Seasonally measured mean values and standard deviations of CO concentration (ppm) in stationary and non-stationary stations at various areas in Kermanshah city.

Station Area	Saturday		Sunday		Monday		Tuesday		Wednesday		Thursday		Friday	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
City center residential	4.00 (1.71)	5.24 (1.02)	3.68 (1.48)	5.22 (2.53)	3.88 (1.50)	5.08 (1.73)	3.38 (1.44)	6.12 (2.72)	3.50 (1.85)	6.36 (1.91)	4.95 (1.34)	2.97 (0.81)	1.90 (0.77)	1.98 (0.42)
Less traffic	2.28 (0.47)	2.49 (0.37)	1.80 (0.3)	3.18 (0.5)	1.80 (0.48)	3.01 (0.94)	1.81 (0.58)	3.74 (1.38)	1.86 (0.67)	3.45 (1.66)	3.32 (0.96)	2.37 (0.59)	0.83 (0.39)	1.20 (0.59)
Commercial	10.79 (3.83)	22.31 (4.95)	9.98 (3.32)	18.49 (3.45)	11.43 (2.73)	19.67 (4.81)	7.54 (2.09)	21.24 (4.16)	13.72 (3.53)	23.41 (4.27)	9.45 (2.55)	9.42 (2.22)	4.28 (1.16)	4.20 (1.85)
Commercial-Industrial	5.49 (1.47)	7.82 (2.72)	4.43 (1.38)	7.29 (2.47)	4.43 (1.38)	6.39 (1.52)	4.64 (1.56)	7.97 (1.45)	4.92 (1.6)	8.66 (2.56)	5.90 (1.42)	3.43 (1.45)	2.75 (0.51)	1.50 (0.35)
Industrial	6.21 (1.51)	8.22 (2.28)	3.56 (1.48)	6.08 (1.73)	3.59 (1.41)	6.24 (1.24)	3.23 (0.86)	6.81 (1.24)	3.99 (0.92)	6.04 (1.31)	4.74 (1.24)	2.55 (0.55)	2.58 (0.51)	2.28 (0.75)

Table 2- Annual mean values and standard deviation of CO concentration (ppm) during weekdays in different stationary stations in Kermanshah city.

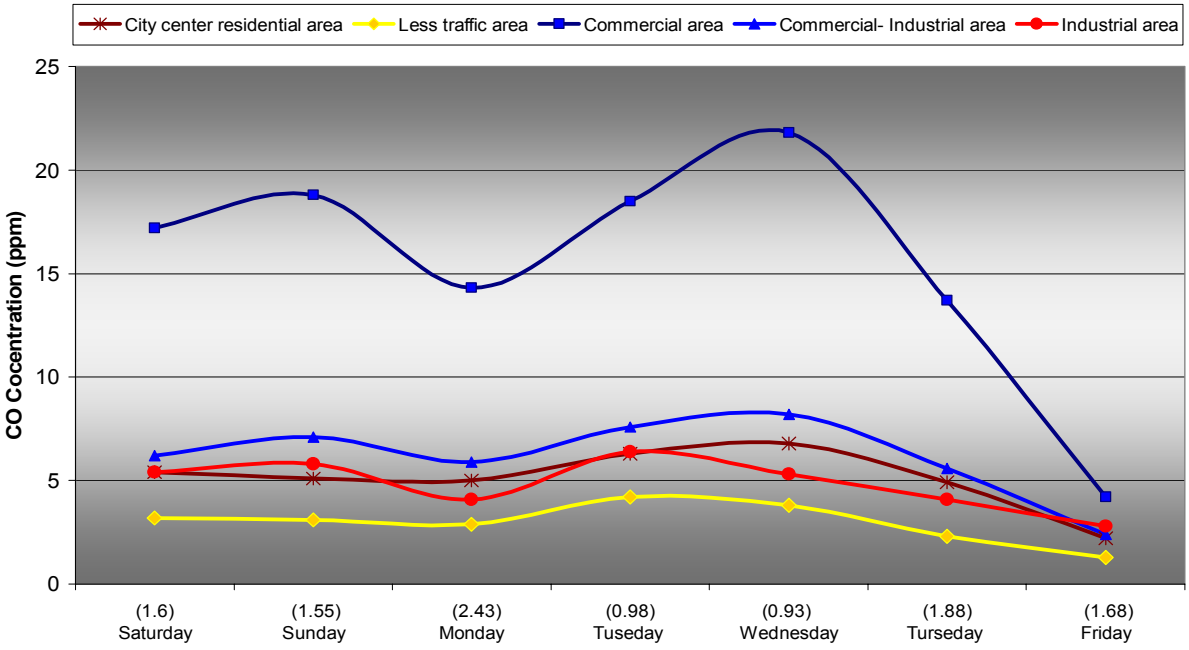

Figure 1: Annual mean value of CO concentrations during weekdays and wind speeds (m/s)

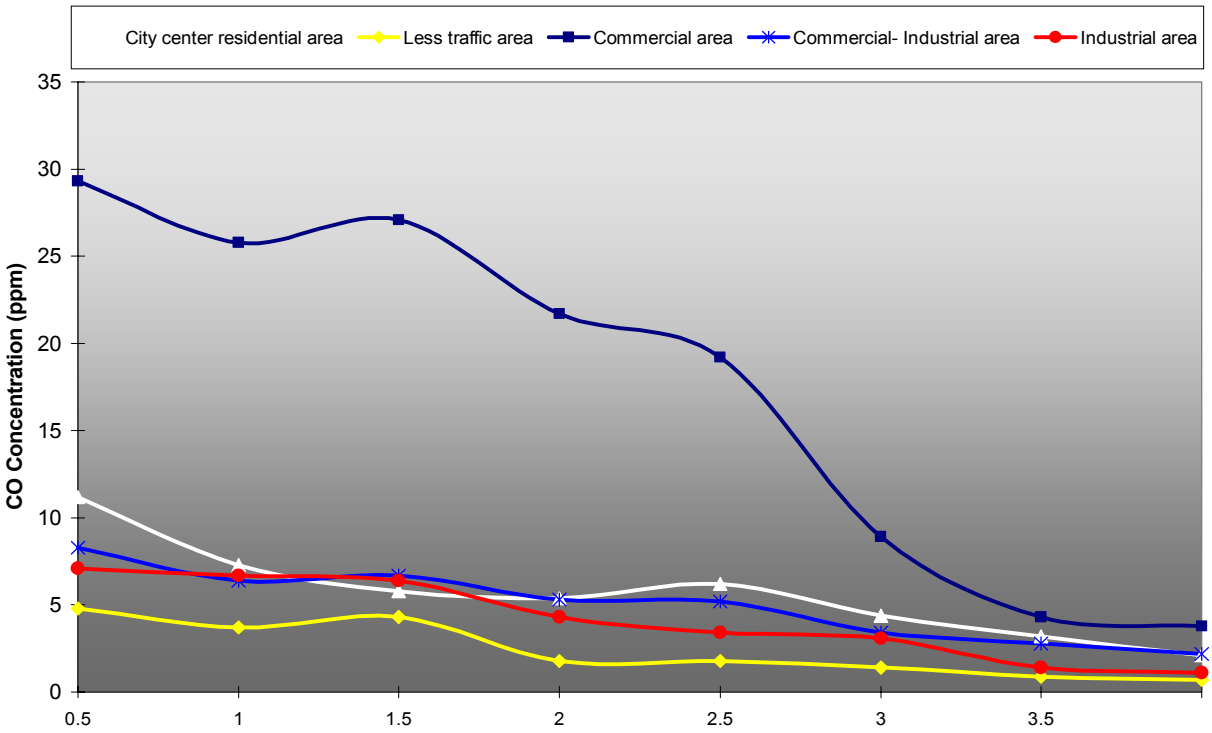

Figure 2: Annually mean value of CO concentration at different wind velocities

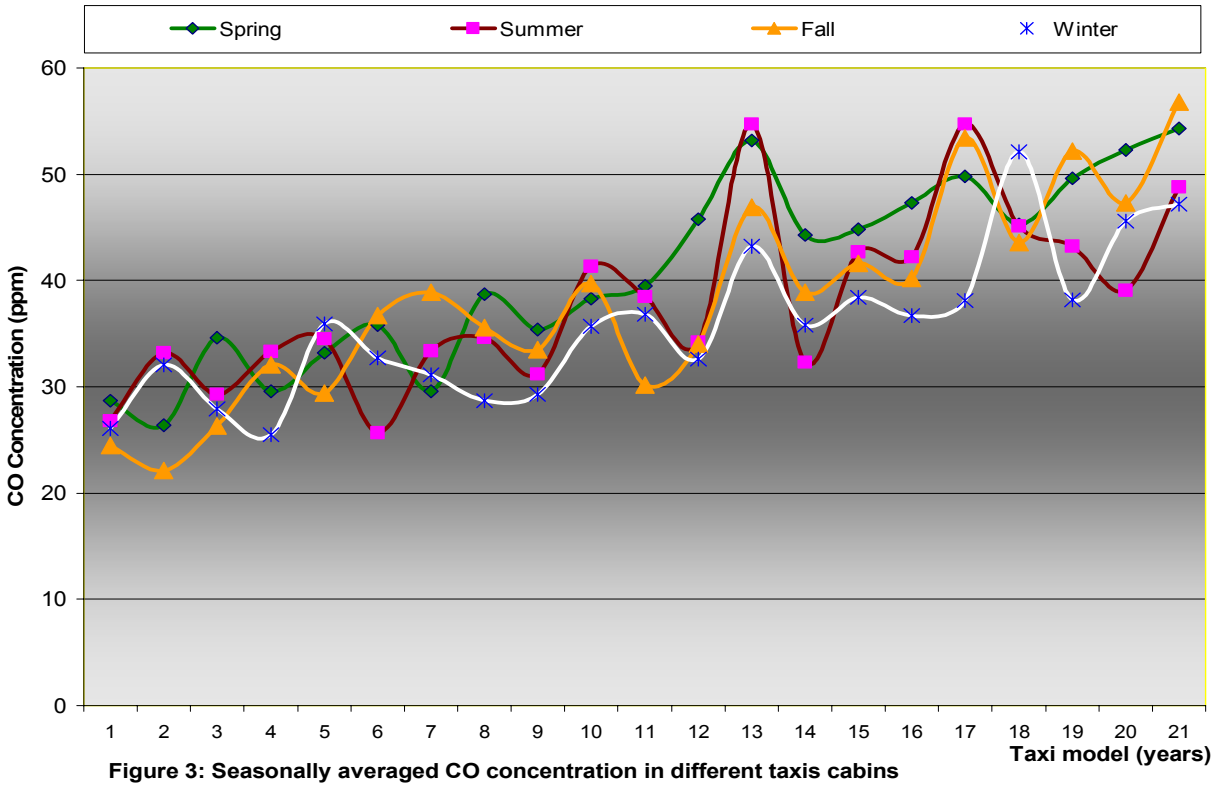

Figure 3: Seasonally averaged CO concentration in different taxis cabins