Atmospheric Pollution due to Carbon monoxide from Vehicular Exhaust in Peshawar

A.R. KHAN, M. AKIF AND M.A. KHATTAK
P.C.S.I.R. Laboratories, Jamrud Road,
Peshawar, Pakistan

(Received 13th May, 1995, revised 8th Feburary, 1996)

Summary: Carbon monoxide is a major air pollutant, its main source being vehicular exhaust. Peshawar, like other major cities is facing a serious problem of air pollution due to rapidly increasing traffic. Carbon monoxide level during 600 hrs to 1800 hrs was studied at sixteen different locations with maximum traffic density. Twelve out of the sixteen locations were found to have an average carbon monoxide concentration above the threshold limits of 9 ppm for 8 hours exposure whereas, at one location average carbon monoxide concentration reached the limit of 35 ppm for one hour average exposure. Results suggest that at these twelve locations, the calculated carboxyhaemoglobin level that could be present in the blood of people exposed for 8 hours are in the range 2.04-4.85% which can adversely affect the central nervous system and can bring changes in psychomotor functions.

Introduction

Anything that adversely affects soil, water, air, living or non living things, directly or indirectly, are termed as pollutants [1]. Air is never found absolutely clean in nature and thus not only natural occurrences such as; volcanic activities, forest fires and vegetation decay but anthropogenic (humans related) activities as well, add huge amounts of pollutants like CO, CO_2, SO_x, H_2S, NO_x, hydrocarbons (HC) etc. continuously [2] to air around us.

Rapid growth in population, increase in transportation and industrial development have contributed significantly in increasing the pollution level. CO is the major individual pollutant with a tonnage nearly twice as great as all other pollutants together [2] produced mainly by transportation. In USA, the total average estimated emission of CO from transportation during 1968-1980 was about 78.3% (w/w) of the total CO emitted by all sources combined [3]. Previously [2] it has been mentioned that almost 59% of CO emission is due to gasoline-fueled vehicles, little share (0.2%) comes from diesel-fueled vehicles. The diesel powered vehicles [4] are the primary culprits in emitting black smoke, NO_x, HCs, SO_x alongwith a nuisance of malodour due to the presence of traces of aldehydes and other oxygenated hydrocarbons. Gasoline vehicles contribute almost 85% of the vehicular carbon monoxide and unburnt hydrocarbon emissions in Indian cities [4]. Published results [5] show that total CO emission in Pakistan due to gasoline-powered vehicles (uncontrolled) increased from about 0.2594 million tons/year in 1980 to 0.6981 million tons/year in 1985 and it was estimated that it would reach about 1.843 million tons/year in 1990. Major part of it has been contributed by the traffic in urban areas [5]. These results [5] further suggest that urban areas have contributed 0.2483 million tons CO/year in 1980 which increased to 0.6693 million tons/year in 1985. The estimated figure for 1990 being 1.754 million tons/year. Previous surveys (unpublished data) carried out at Karachi have indicated that huge amounts of air pollutants are contributed by industries. Carbon monoxide alongwith other gaseous pollutants were monitored at the important intersections of Karachi city. This survey also covers the pollution due to power plants, refineries, and industries.

Carbon monoxide is a very toxic gaseous pollutant which can seriously affect human aerobic metabolism owing to its high affinity [1] for haemoglobin, the component of the blood responsible for the transport of oxygen. CO reacts with haemo-globin (Hb) of blood to give carboxyhaemoglobin (COHb), thus reducing the capability of the blood to carry oxygen. Literature [3] suggests that in the presence of oxygen the affinity of haemoglobin for CO is 200 times greater than oxygen. Longer persistence (about 2.5 months atmospheric mean life) of this pollutant as estimated by Peavy *et al.* [3] in the air makes it more dangerous for the human beings.

Health risk associated with CO can put serious consequences on the whole population in general and those living in congested and populous cities of Pakistan having high traffic densities, in particular. As, no one has so far gauged the level of CO in Peshawar, a comprehensive study in this area was considered necessary. This paper examines the state of CO pollution due to traffic in Peshawar. It offers remedial measures to reduce the menace of CO pollution.

Results and Discussion

For monitoring purpose, Peshawar was divided into City, G.T. Road and Cantonment areas. Sixteen different locations with high traffic density were selected carefully to give a representative picture of Peshawar, Figure 1 shows the detail of the study points.

Carbon monoxide concentrations (Table-1) of the locations mentioned in Figure 1 show the average hourly, 8 hourly and 12 hourly data. During traffic jams the CO concentration shoots up abruptly with in fractions of a minute becoming a health hazard for human beings. Table 1 shows the highest reading recorded during traffic jams at different locations. These results suggest that 8 hours average of twelve out of sixteen locations have CO level higher than the permissible limit of 9 parts per million (ppm) [3]. Previously, the tolerance level of CO has been reported [6] to be 32 ppm, the relative toxicity weighting factor being 1.

Carbon monoxide concentration and traffic density are directly related. However, other factors are also important, like, the location, wind velocity, humidity, temperature etc. Higher the wind velocity and more open the area around the location, lower would be the CO level. Similarly high temperature alongwith higher wind velocity would increase the rate of diffusion which would enhance the dissipation of CO soon after emission. Hayatabad, Board of Intermediate and Secondary Education and Speen Jamat Chowks (Table-1) are quite open compared to the rest of locations, as a result lower CO concentration is obvious. Another important factor is the number of gasoline-fueled vehicles. Table-1 substantiates the higher CO emissions due to higher traffic density at thirteen locations. These results are in agreement with that of the published ones [2,5].

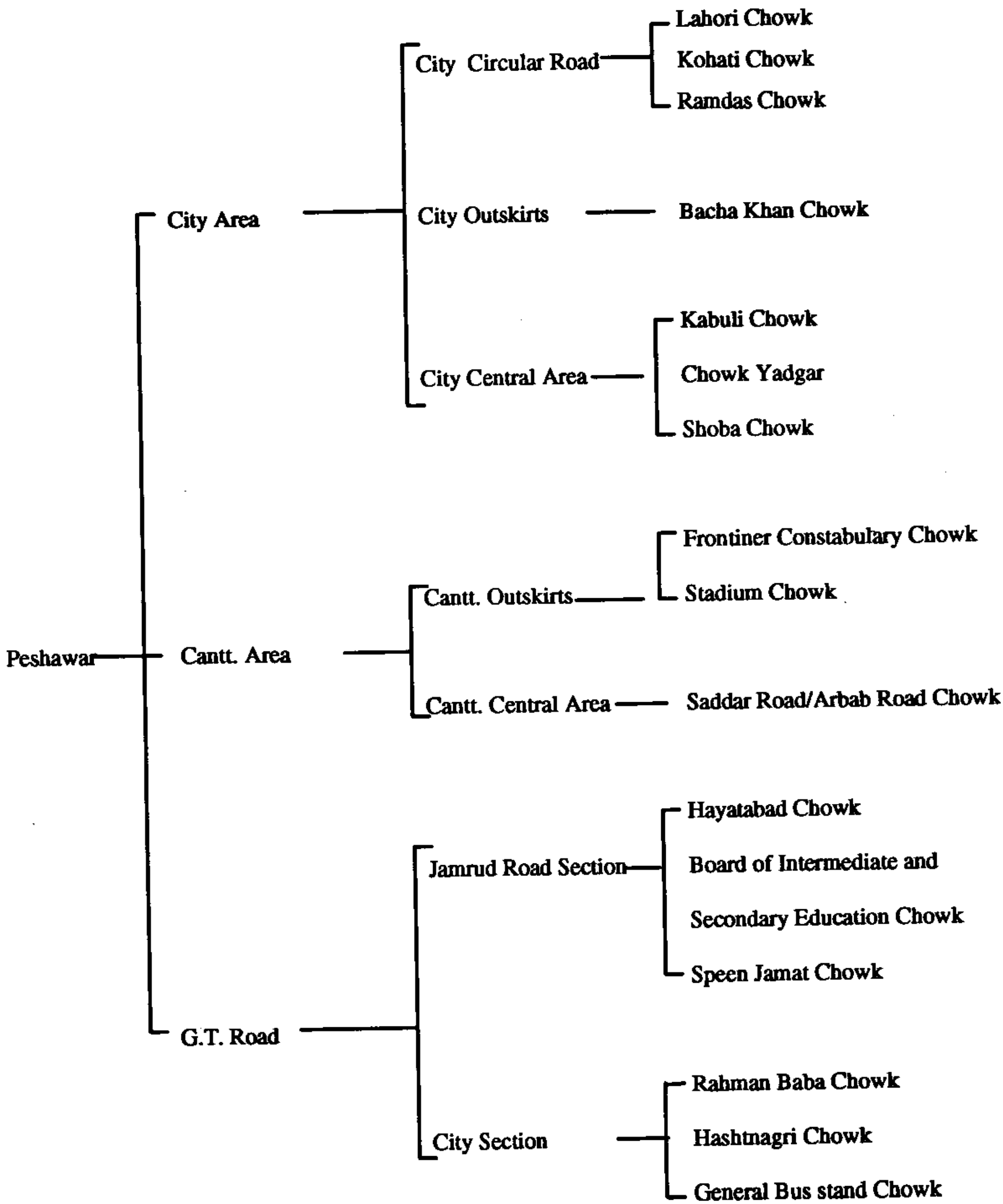

Fig. 1: Peshawar city, its location and study points.

Table-1: Carbon monoxide level, percentage of gasoline-fueled vehicles and equilibrium concentration of blood carboxyhaemoglobin

Location (Chowk)	Average CO concentration ppm			Highest readings (ppm)#	Gasoline fueled vehicles (%)	Equilibrium concentration of blood COHb-Air CO level (%)*
	1 hour	8 hours	12 hours			
Hayatabad	5.50 ± 0.35	5.00 ± 0.39	4.89 ± 1.29	–	45.20	1.30
Board of Intermediate & Secondary Education	7.60 ± 0.50	6.74 ± 0.51	5.76 ± 1.70	44	47.01	1.58
Speen Jamat	9.95 ± 0.64	7.60 ± 0.77	6.80 ± 1.71	40	45.30	1.72
Rahman Baba	19.80 ± 2.30	16.10 ± 2.69	14.47 ± 2.98	97	62.95	3.08
Hashtnagri	14.24 ± 2.21	11.30 ± 1.53	10.57 ± 1.68	30	60.00	2.31
General Bus Stand	10.95 0.92	9.60 ± 0.87	9.00 ± 1.31	54	50.00	2.04
Lahori Gate	18.26 ± 2.06	12.90 ± 2.64	11.70 ± 1.98	55	65.00	2.56
Kohati Gate	17.40 ± 2.55	10.80 ± 1.95	9.63 ± 1.95	41	60.00	2.23
Ramdas	23.40 ± 0.49	20.50 ± 2.53	15.82 ±3.01	126	70.00	3.78
Frontier Constabulary	22.57 ± 1.37	18.50 ± 1.86	16.57 ± 3.05	82	60.00	3.46
Peshawar Stadium	18.55 ± 1.34	15.56 ±2.30	13.56 ± 2.90	73	80.00	2.99
Shoba	22.35 ± 1.91	17.74 ± 2.46	15.24 ± 3.30	58	60.00	3.34
Bacha Khan	23.63 ± 0.88	19.74 ± 3.16	16.80 ± 3.57	73	70.00	3.66
Chowk Yadgar	34.92 ± 1.76	27.21 ±2.82	22.53 ± 3.59	74	98.00	4.85
Arbab/Saddar Rd.	25.90 ± 0.71	18.50 ±2.36	16.09 ± 3.59	80	80.00	3.46
Kabuli	25.80 ± 0.71	21.94 ± 2.98	18.78 ± 3.89	72	75.00	4.01

*based on 8 hours average #persists only for few seconds during the traffic jam

Table-2: Climatic* data of Peshawar (1992)

Month	Temperature °C		Humidity %		Max. wind speed and direction
	Max.	Min	800 hrs	1700 hrs	
September	34.6	22.0	78	58	SW 35 km/hr
October	31.0	15.9	79	50	NW 35 km/hr
November	25.8	9.4	78	57	E 25 km/hr

*Meterological Deptt, P.A.F. Base, Peshawar.

There is a general trend that emission of CO vary with the change in traffic density. Generally, CO increases between 800 and 900 hrs (Figure 2) when the people leave for their work places and students go to their institutions. Figure 2 suggests a general trend of CO variation and traffic density at a point (Ramdas Chowk). Commercial activities reach at their peak between 1000 and 1300 hrs. At about 1400 hrs traffic density gets lower thus reducing the CO emission. After 1400 hrs traffic starts increasing subsequently raising the CO level.

It has been observed that an abrupt and comparatively higher increase in CO after 1800 hrs occurs with a little rise in traffic density [7]. Furthermore, apparent fog in bulb lights, irritation to eyes and presence of visible dust in the evening in the ambient air have been observed during the survey. This increase in CO concentration could be attributed to a decrease in temperature which reduces the rate of diffusion compared to that in the afternoon. Table-2 shows the climatic data (from Metrological Department, P.A.F. Base, Peshawar) for the months when these studies were undertaken. One can easily guess from the data presented in Table-2 that there is a significant decrease in the temperature in the evening suggesting a lower diffusion rate.

Literature [2] suggests that the level of COHb in the blood is directly related to the CO concentration of the inhaled air. COHb level in the blood will reach an equilibrium concentration after a sufficient time period for a given CO concentration in ambient air. This equilibrium is maintained as long as ambient air CO level remains unchanged. A new equilibrium is established slowly with the change in CO

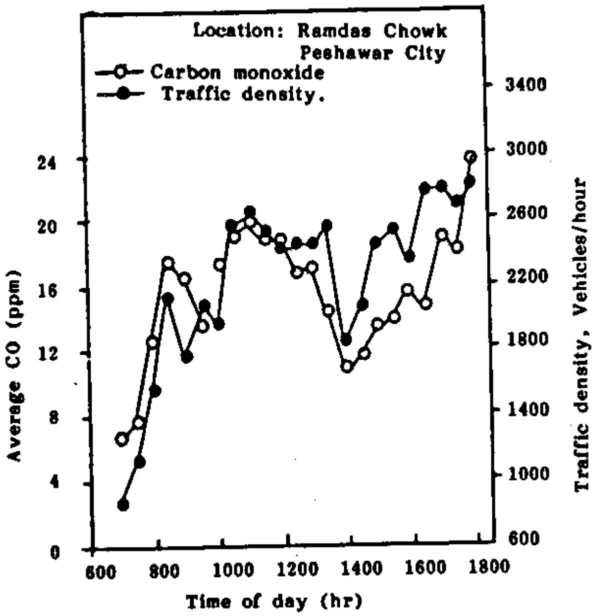

Fig. 2: Daily variation of Carbon monoxide level with traffic density.

Table-3: Health effects of COHb blood levels

COHb blood level (%)	Demonstrated effects [8]
Less than 1.0	No apparent
1.0 to 2.0	Some evidence of effect on behavioural performance.
2.0 to 5.0	Central nervous system effects. Impairment of time interval discrimination, visual acuity, brightness discrimination and certain other psychomotor functions.
Greater than 5.0	Cardiac and pulmonary functional changes.
10.0 to 80.0	Headache, fatigue, drowsiness, coma, respiratory failure, death.

concentration in the surrounding. The background level of blood COHb is about 0.5% [2] which comes mainly from the destructive metabolism of heme, a component of haemoglobin and ambient air CO. The equilibrium percentage of COHb in blood stream of a person exposed to less than 100 ppm CO can be estimated by the equation:

% COHb in blood = 0.16 (CO concentration in ppm) + 0.5

where 0.5% is the normal background COHb in blood. Using the above equation, blood COHb-Air CO equilibrium data for different locations have been calculated (Table-1). The calculated blood COHb level in the people exposed for 8 hours is in the range of 2.04-4.85% with the exception of Hayatabad, Board of Intermediate and Secondary Education and Speen Jamat chowks where this level is less than 2%. Wolf [8] has described the adverse effects on the humans (Table-3). Thus 2-5% blood COHb may affect the central nervous system, impair time interval discrimination, cause visual acuity, affect discrimination of brightness and may change certain other psychomotor functions. When this situation is supplemented with other gaseous pollutants of automobile exhaust like HC, SO_x, NO_x dust etc. a bleak picture can be visualized.

Experimental

COTEC model CM-2B carbon monoxide digital mini monitor, Gastec Corporation, Japan was used for monitoring the CO concentration. This instrument was calibrated with 50.0 ppm standard carbon monoxide gas supplied in a 2.5 L cylinder by Gastec Corporation, Japan, after suitable intervals between its use. Special plastic sampling bag (supplied with the kit) was filled with the gas by connecting it with the cylinder. The standard gas filled in the bag was carried to the sensor of the instrument by connecting the bag with the instrument through a pump (Gastec Corporation, Japan) supplied for this purpose.

Carbon monoxide concentrations were recorded from 600 hrs to 1800 hrs at a constant height of about four feet above the ground. The data under report is an average of 20-50 readings taken half hourly.

Conclusion

This paper concludes that Peshawar is badly polluted by CO mainly emitted by automobiles. Gasoline-fueled vehicles are responsible for the deteriorating situation of pollution in Peshawar. There is a dire need to keep the vehicles tuned, vehicles with faulty and worn out engines should be removed from the roads. Avoiding traffic jams by keeping away the slow moving traffic from the main roads and removing the encroachments made by vendors and shopkeepers would help in reducing the pollution level in Peshawar.

References

1. S.S. Shamsi, *Engineering Horizon*, **3**, 21 (1992).
2. Environmental Chemistry: Air and Water Pollution, H.S. Stoke and S.L. Seager, Scott, Foresman and Company, USA (1972).
3. Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous, McGraw-Hill Book Company, New York (1986).
4. B.P. Pundir, S. Das and R. Krishna, *Res. and Industry*, **32**, 240 (1987).
5. N.A. Khan, *Sci. Technol and Development*, **6**, 25 (1987).
6. L.R. Jr. Babcock, *J. Air Pollution Control Assoc.*, **20**, 653 (1970).
7. Environmental pollution caused due to carbon monoxide from vehicular exhaust in Peshawar, A.R. Khan, M. Akif, M.A. Khattak, PCSIR Peshawar, Report (1993).
8. P.C. Wolf, *Environmental Sci. and Technol.*, **52**, 212 (1971).