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Health Risk Assessment of Workers in Underground Parking Due to Exposure to CO and VOC

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ABSTRACT

Indoor air quality monitoring was done in underground car parking with an objective to assess the health risk of workers due to VOC (Volatile organic compounds) and CO (Carbon Monoxide). VOCs are measured using glass sorbent activated charcoal tubes and VOC monitor and analysis was done using GC-MS and CO concentration is measured instantaneously using MQ9 sensor. Health risk of the workers was assessed by evaluating the non-cancer and cancer risk and hazard quotient (HQ). The cancer risk of benzene and other VOCs exceeded the safe value of 1 in Million. Carboxyhemoglobin (COHb) concentration varied from 0.98% to 1.45%.

Keywords: VOC, CO, Health risk assessment, Cancer risk, Non-cancer risk, Car parking, Indoor air pollution

INTRODUCTION

The car parking, especially the underground parking, acts as a microenvironment in which the pollutants of concern are accumulated and cause serious health threat to people working inside. The extent of the pollution in the microenvironment can be comprehended from the fact that about 1 of 24 hour life of automobiles in the cities pass in the driving state and the rest 23 hours pass in parking state [1]. The air pollution caused by motor vehicles and specifically cars in parking has persistent and harmful effects on environment and human health. In parking, the increase in exhaust emissions, running losses and resting losses in closed areas and insufficient ventilation may cause accumulation of these pollutants beyond permissible limits. The main exhaust emissions which are being studied are CO (Carbon Monoxide) and the VOCs (Volatile Organic Compounds) [2-10]. These studies also documented the possible harmful effects of these pollutants on human health [2-10]. In this study an attempt was made to predict the health risk associated with the workers in car parking in Chandigarh (India).

MATRIALS AND METHODS

The CO measurements and VOC sampling was done in three different parking locations in Chandigarh (Inida). The study was conducted in the underground parking as indicated in Table 1.

Table 1: Characteristics of different locations chosen for study

S. No.	Location	Area (m^2)	Capacity/ number of cars	Type of establishment
1.	Location 1	1000	250	Health care
2.	Location 2	2000	800	Commercial
3.	Location 3	1500	400	Commercial

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CO Measurements

Carbon monoxide was measured instantaneously using carbon monoxide sensor attached to the microcontroller and gives instant readings for the CO levels on display. The sensitivity material used in MQ9 sensor is SnO_2. The sensor operates within the range of -10 to 50^0C and consumes less than 150 mA at 5V.

VOC Sampling

Active air sampling was conducted at 3 parking. Measurements were made on working days for a period of 8 hours. Low flow VOC sampler was used to sample the indoor air at three different locations. The testing methodology complied with US EPA Compendium Method TO-17 and EPA Method 8260B.

RESULTS

For exposure and risk assessment, the following assumptions regarding individual exposure were made based on the best professional judgment and questionnaire data.: (i) the amount of air breathed was taken as $1.2m^3/h$ [11] and (ii) an entire lifetime of 70 years was applied and the work lifetime is assumed to be 30 years (iii) the average body weight of workers was derived from the questionnaires used for the survey (iv) the inhaled toxicants were assumed to be totally absorbed for risk calculations. Hence, the absorption factor of VOCs for humans was assumed to be 100%. [12-13] (v) average number of hours spent per day in the car parking was taken as 10 h (vi) 6 to 7 days/week which results in approximately 44 work weeks each year (vii) exposure to VOCs was based on the average -h (full shift) time weighted average (TWA) concentration.

Carboxyhaemoglobin levels in parking employees

The CO poisoning is expressed in terms of %COHb levels of the employees working in car parking. Table 2 indicates the %COHb and average CO concentration inside the car parking during 8-hour period of continuous monitoring.

Table 2:%COHb levels due to exposure to CO

S.NO.	Study Area	Average CO (ppm)	%COHb
1.	Location 1	6.83	1.25%
2.	Location 2	5.12	0.979%
3.	Location 3	8.13	1.45%

Chronic daily intake of the VOCs by workers in parking

The inhalation intake (I) or CDI (Chronic Daily intake) was used to assess carcinogenic risk and non-carcinogenic effects from chronic exposure and was calculated by averaging daily intake over the exposure period. Table 3 shows the CDI in the different sampling locations.

Table 3: CDI for both cancer and Non-cancer risk for different parking

S.No.	VOCs	Basement location 1		Basement location 2		Basement location 3	
		Cancer	Non-Cancer	Cancer	Non-Cancer	Cancer	Non-Cancer
1	Benzene	0.1665	0.3886	0.2690	0.6276	0.1866	0.4353
2	Bromoform	0.6741	1.5730	0.6627	1.5463	0.7096	1.6558
3	Toluene	0.2913	0.6797	0.2135	0.4981	0.2564	0.5982
4	ethylbenzene	0.3004	0.7010	0.2335	0.5448	0.2907	0.6783
5	1,2-dichlororbenzene	0.6638	1.5489	0.2684	0.6263	0.4784	1.1163

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Cancer risk

Cancer risk is estimated as the probability of developing cancer from a lifetime of continuous exposure to VOCs. The lifetime cancer risk was estimated using the equation [11 – 13]:

$$R = C \times P$$

Where,

R = cancer hazard risk

PF = cancer slope factor (kg.day/mg) or potency factor

Risk less than 1 in Million ($1x10^{-6}$) are typically considered to be well below a level of concern, and risk above 100 per million ($1x10^{-4}$) is considered sufficient that some action or intervention is necessary [14]. Table 4 depicts the estimated cancer risk associated with benzene at the three locations.

Table 4: Cancer risk

Location	Cancer Risk
Location 1	0.004546
Location 2	0.007343
Location 3	0.005093

Non-cancer risk

Unlike cancer risk, non-cancer risk is expressed in terms of the hazard quotient (HQ), which is defined as the ratio of the estimated exposure of an individual to the reference dose. The R_fD (mg/kg.day) is a numerical estimate of the daily exposure to the human population, including sensitive subgroups such as children, that is not likely to cause harmful effects during a lifetime [14]. The non-cancer health impacts were expressed as the hazard index (HI), which is determined by calculating the HQ for each contaminant and summing all of the HQs at a specific location for which the assessment is being made. For a given pollutant, exposures below the reference level (HI < 1) are unlikely to be associated with adverse health effects. The potential for adverse effects increases when the exposure concentrations start to exceed the reference dose. Hazard quotient is the ratio of the measured intake concentration of the pollutant to the reference dose. Table 5 tabulates the Hazard Quotient for the VOCs along with hazard index (HI). HI more than 1 warrants strict VOC control in underground parking.

Table 5: HQ for VOCs

VOCs	Hazard Quotient		
	Location 1	location 2	Location 3
Benzene	45.34	73.23	50.79
Bromoform	78.65	77.31	82.79
Toluene	5.96	4.37	5.25
Ethylbenzene	2.45	1.90	2.37
1,2-dichlororbenzene	17.21	6.96	12.40
Hazard Index	**1.5**	**1.6**	**1.5**

CONCLUSIONS

The present study was aimed to assess the health risk of workers in underground car parking The study indicated that the cancer risk estimated due to benzene exposure exceeded the safe value of One in Million and the safety threshold value of Hundred in Million. Non cancer hazard due to VOCs, based HQ calculated, exceeded the value of 1 and thus emphasizing the need to control VOC emissions. %COHb levels ranged from 1 – 1.5% and therefore, exposure to longer duration may cause significant health effects.

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