Carbon Monoxide Fractions in Cigarette and Hookah (Hubble Bubble) Smoke

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Abstract

We studied the carbon monoxide (CO) fractions in hookah and cigarette smoke, using a carbon monoxide micro smoker lyzer (model EC50, BEDFONT. U.K.). Mean carbon monoxide fractions (% by volume) of hookah smoke, using domestic charcoal were 0.38±0.07 (large hookah; unfiltered); 1.40±0.43 (small hookah; unfiltered); 0.34±0.06 (large hookah; filtered); 1.36±0.35 (small hookah; filtered) and 0.41±0.08 (cigarette smoke). The highest fractions were obtained with small size hookah and increase in size of hookah (i.e., volume of air in water base, fire bowl volume, pipe length, etc.) reduced the CO fraction significantly ($P<0.001$). The fractions of cigarette lie between large and small hookah. The fractions vary slightly with different varieties of tobacco, e.g., CO fractions with Dera wala tobacco are significantly low ($P<0.05$). Use of commercial charcoal gives significant rise in CO fractions ($P<0.001$). Comparison of filtered and unfiltered smoke shows no significant difference in values. We conclude that the CO hazard is as high with hookah smoking as with cigarette smoking (JPMA 43: 79, 1993).

Introduction

The hookah (hubble bubble, water pipe) is commonly used in the Indo-Pak subcontinent and is considered harmless as the smoke is filtered through water. The organic compounds produced at high temperature are condensed and retained in the water. We have analyzed another component found in the tobacco smoke, CO, which has toxic effects when inhaled because of it's competitive binding with haemoglobin to form carboxyhaemoglobin. Carbon monoxide (CO) is produced during incomplete combustion of organic matter. We measured the content of CO in the smoke of various brands of cigarettes and of the tobacco used in hookah and determined the effect of hookah size and the presence of the water filter.

Materials and Methods

Hookah tobacco was procured from 3 different sources: 1) Desi Punjab, 2) Dera wala (mixed with molasses) and 3) Desi patti dry (Table, I).

Table I. Carbon monoxide fractions in hookah smoke using three different varieties of tobacco and domestic charcoal.

Tobacco Type		Hookah type			
		Large		Small	
		Unfiltered	Filtered	Unfiltered	Filtered
1	Mean	0.43	0.39	1.90	1.7
	SD	0.03	0.05	0.14	0.2
2	Mean	0.30	0.28	1.10	1.00
	SD	0.02	0.03	0.08	0.09
3.	Mean	0.41	0.36	1.20	1.30
	SD	0.05	0.03	0.11	0.09
	Overall mean	0.38	0.34	1.40	1.30
	SD	0.07	0.06	0.43	0.35

Thirteen grams (the quantity approximately equal to that commonly used) of each tobacco type or tobacco mixed with molasses was used for quantification. There were two types of hookah, large and small with following detail of; components: Large: Fire bowl volume = 705 ml; stem length = 80 cm; suction pipe length = 1.2m; base volume = 800 ml; Small: Fire bowl volume = .75 ml; stem length = 40 cm; suction pipe length = 70 cm; base volume' = 400 ml. The domestic charcoal, prepared by burning soft wood (bark of tree, acacia) was used in measurements of both type of hookah. In order to see effect of the charcoal on CO component of smoke, commercial charcoal, prepared by burning hard wood (stem and branches of tree, generally acacia, under oxygen deficient earthen ovens) was also used for another set of measurements on large hookah (Table II).

Table II. Carbon monoxide fractions in tobacco smoke using different varieties of tobacco and commercial charcoal.

Tobacco type		Filtered	Unfiltered
1	Mean	2.23	2.30
	SD	0.04	0.13
2	Mean	1.71	1.50
	SD	0.39	0.18
3	Mean	2.32	2.36
	SD	0.07	0.13
Overall mean	2.09	1.95	
SD		0.32	0.65

The different brands of cigarettes selected for evaluation are given in Table III.

Table III. Mean carbon monoxide levels in different brands of cigarettes commonly available in market.

S.No.	Brand name	Carbon monoxide Fractions (%)	
		Mean	SD
1	Royals	0.27	0.02
2	More	0.49	0.04
3	Red and white	0.52	0.04
4	Embassy	0.46	0.07
5	K-2	0.43	0.06
6	Gold Leaf	0.36	0.03
7	Gold Flake	0.47	0.04
8	Capstan	0.37	0.05
9	Morven Gold	0.33	0.08
Overall mean	0.41		
SD	0.08		

Cigarettes vs large hookah, highly significant ($P < 0.001$).
Cigarettes vs small hookah, highly significant ($P < 0.001$).

Mean weight of tobacco per cigarette was 0.93g (SD= 0.10). Mean lengths of tobacco column and filter were 7.2cm (SD =1.3) and 1.18 cm (SD = 0.2) respectively, with approximately 0.5 cm diameter. A vacuum pump (Sartorius) which sucks the smoke from the source under a constant pressure 1100 mbar(76 Torr)] was used to take smoke samples. The smoke was collected for 30 seconds in rubber balloons to estimate the volume of gas produced. The volume was calculated by displacement of measured quantity of water (Figures 1 and 2).

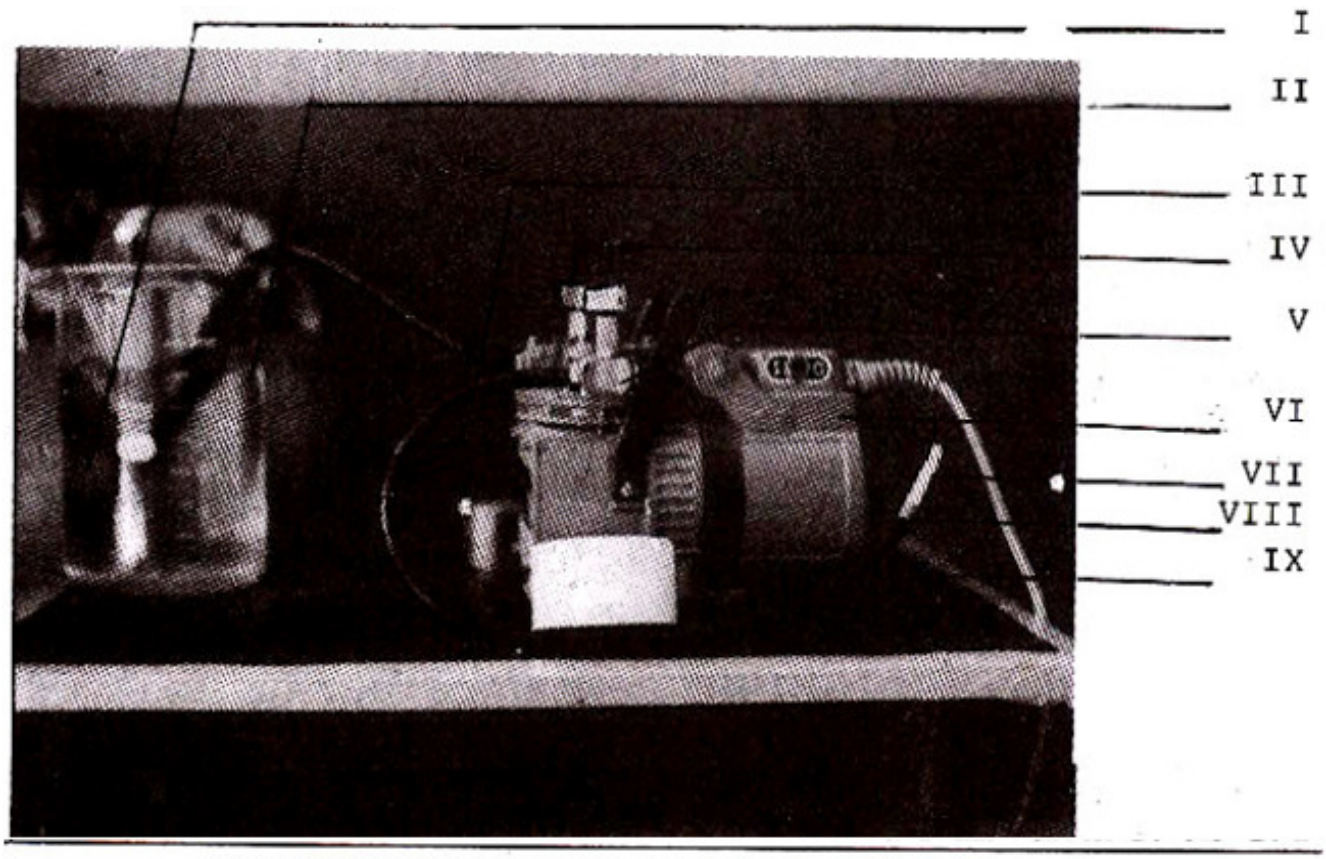

Figure 1. Experimental set up for collection of hookah smoke.

I) Suction pipe; II) Mouth piece; III) Rubber pipe leading to vacuum pump; IV) Clay head or fire bowl with tobacco at the bottom covered with live coals; V) Stem leading to water container; VI) Collection pipe leading to balloon; VII) Container with measurable quantity of water and balloon; VIII) Vacuum pump; IX) Base containing water through which smoke passes for cooling and dissolving soluble compounds like nicotine and tar.

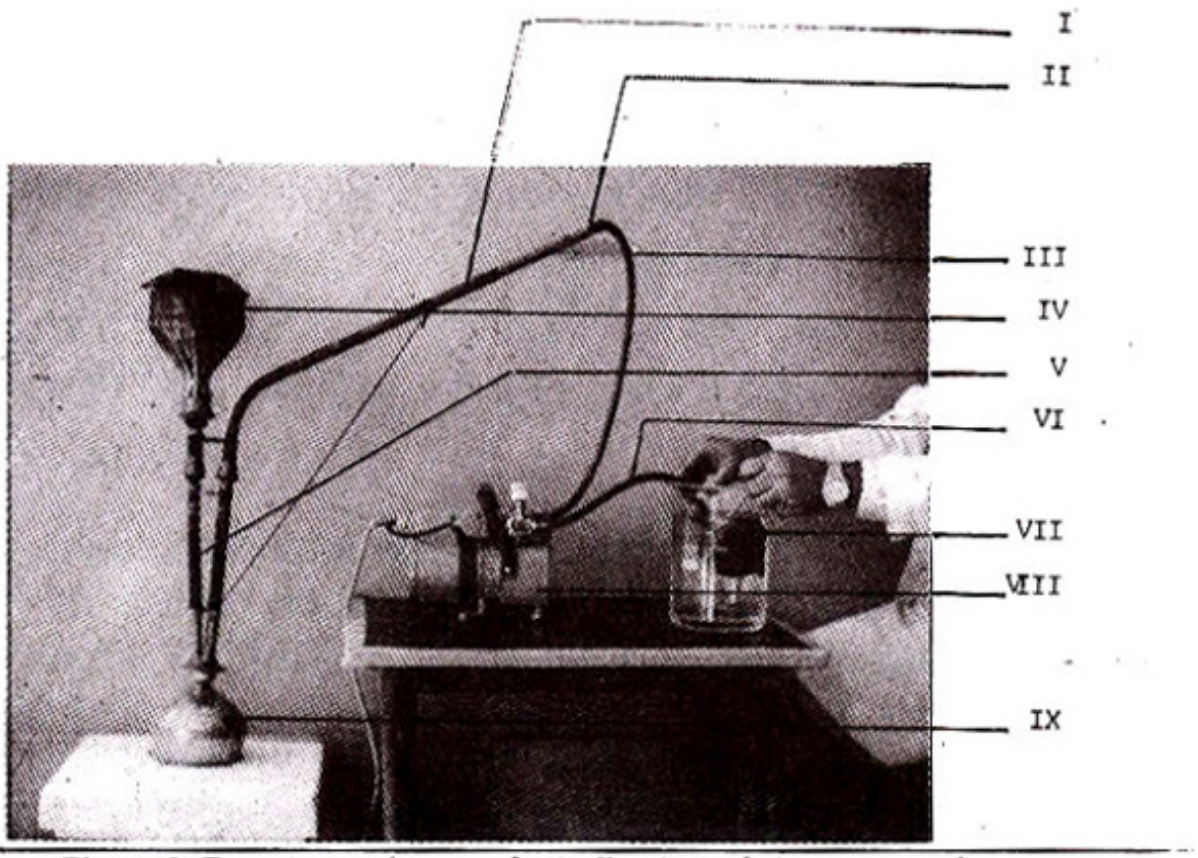

Figure 2. Experimental set up for collection of cigarette smoke
I) Balloon; II) Container with measurable quantity of water; III) Rubber pipe leading to vacuum pump; IV) Inlet of vacuum pump; V) Outlet of vacuum pump; VI) Vacuum pump; VII) Cigarette; VIII) Cigarette filter; IX) Smoke collection pipe.

In the hookah the volume of smoke ranged between 2.4 and 4.6 litres (mean= 4.02, SD= 0.91), whereas in cigarettes, the estimated smoke volume was between 2.77 and 3.98 litres. Smoke analysis with EC5O micro smoker lyzer was performed following instructions of the manufacturer[1]. As the analyzer is very sensitive, the smoke had to be diluted to 1:20 with air. Measurements on collected smoke were carried out at ambient temperature (30°C) and pressure (1025 mbar). The recommended working range of the equipment (EC5O micro smoker lyzer, BEDFONT, U.K.) is 0-500 pmm (0-0.05% vol.). We therefore had to improvise and develop a modified procedure for measurement of very high fractions of CO in cigarette and tobacco smoke. Preliminary measurement was carried out using the following procedure: 200 ml of hookah smoke was drawn into a plastic syringe by suction from the balloon. The syringe was then attached to the sampling system of the instrument through the calibration adapter (see Figure 3)

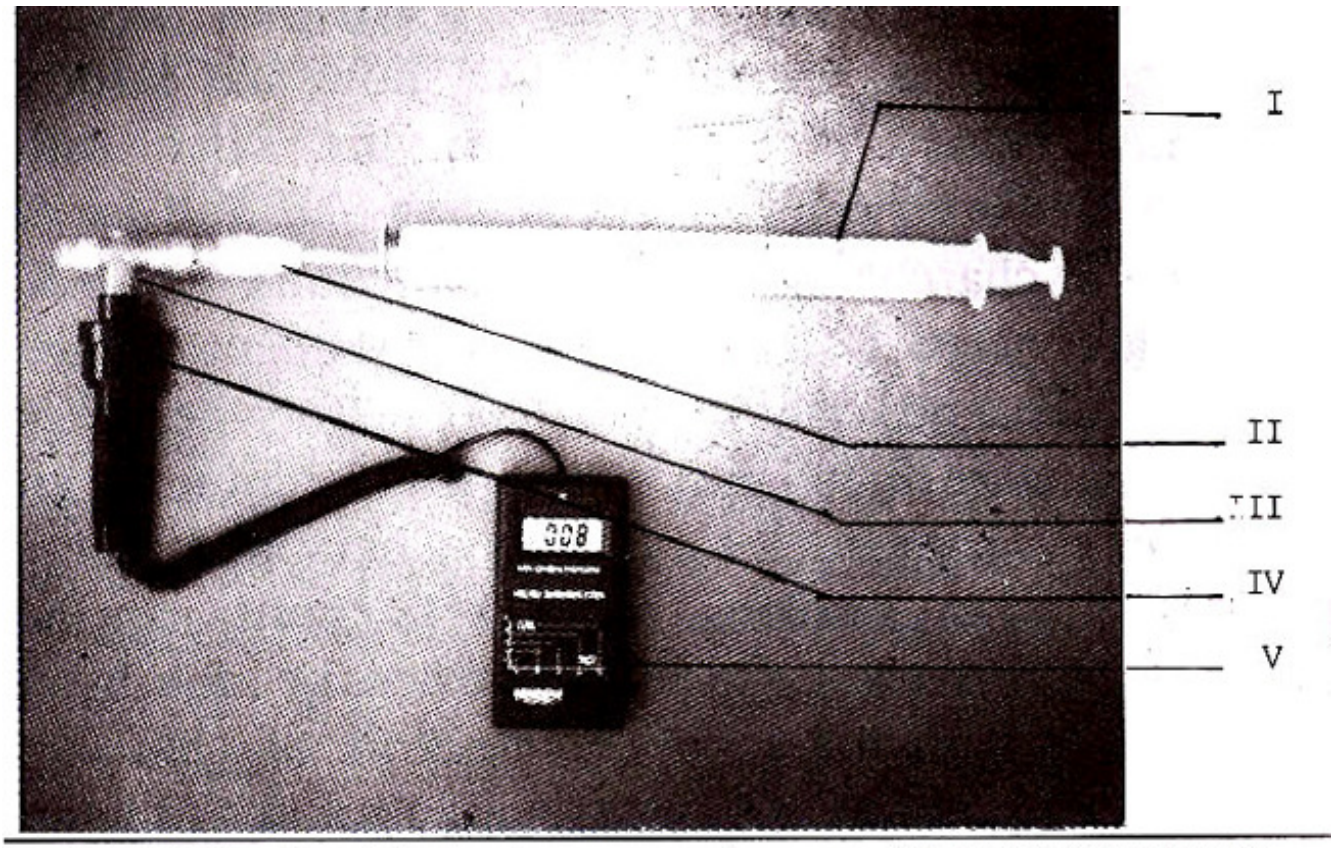

Figure 3. Experimental set up to measure carbon monoxide level in diluted smoke sample.; I) Disposable syringe containing smoke sample; II) Calibration adapter; III) Sampling system; IV) Remote handled sensor; V) Model EC50 Microsmokerlyzer.

and the smoke was gently forced into the sampling system. The instrument was operated following the instructions of the manufacturer. It was not possible to take the reading, as the value exceeded the maximum value of the instrument. Diluted smoke sample had, therefore, to be used in the measurements. Details of standardization of the procedure for measuring CO fractions in smoke are:

1. Zero adjustment and calibration of the equipment

Air background was eliminated by using zero adjustment control. For calibration, CO at 50 ppm in aerosol container (BEDFONT, U.K.) was connected to sampling system. The span control was used to display 50 ppm (Figure 4).

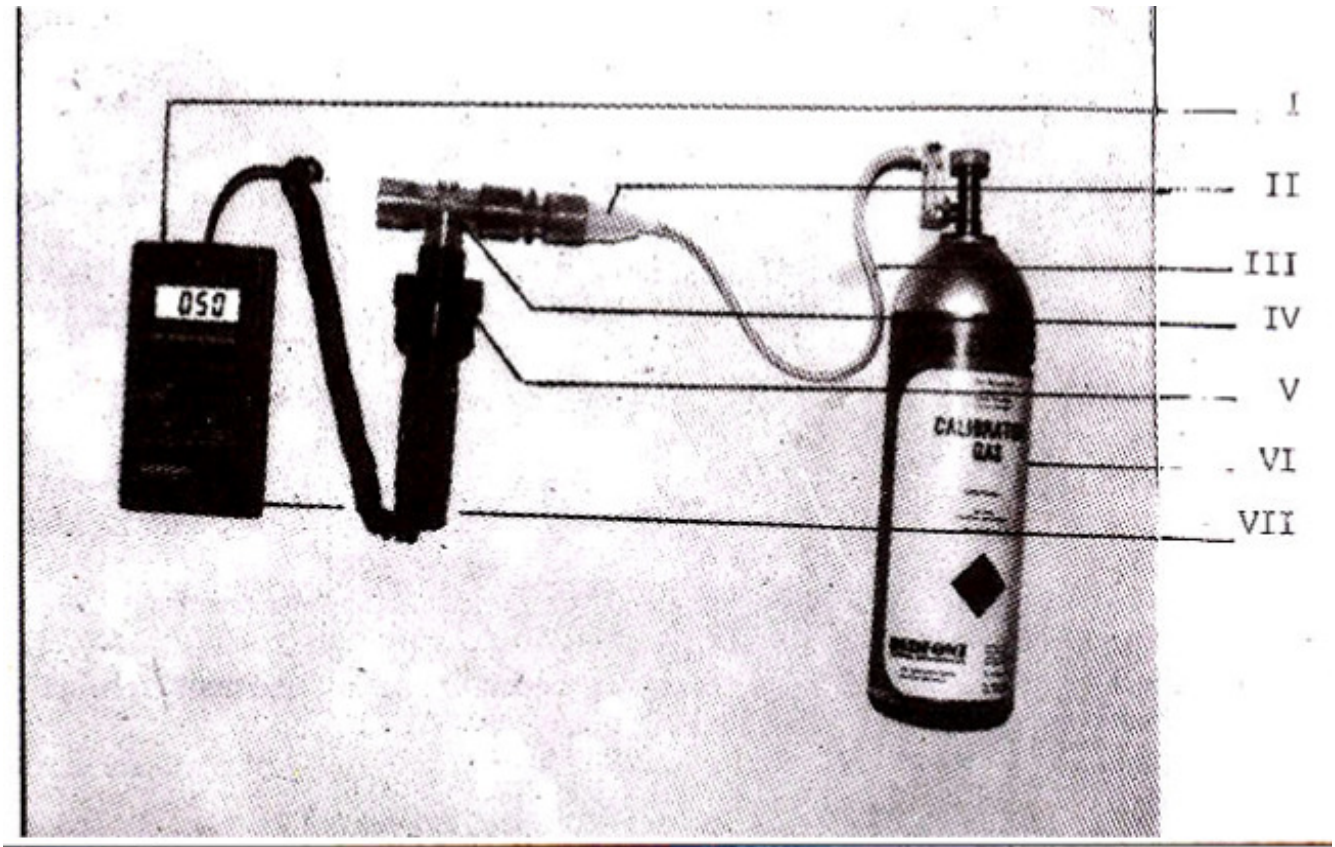

Figure 4. Set up for calibrating EC50 Microsmokerlyzer.; I) EC50 Microsmokerlyzer; II) Calibration adapter; III) Rubber pipe connecting calibration gas to sampling system; IV) Sampling system; V) Remote handled sensor; VI) Calibration kit (aerosol cannister filled with 50 ppm CO).

2. Selection of sample volume

Different volumes of calibration gas Collected in plastic syringe were forced into the sampling system of the equipment. The values recorded at volumes greater than 180 ml are almost close to the calibrated value (50 ppm). The efficiency of the system at sample volumes greater than 200 is fairly good, La, 98% (Figure 5).

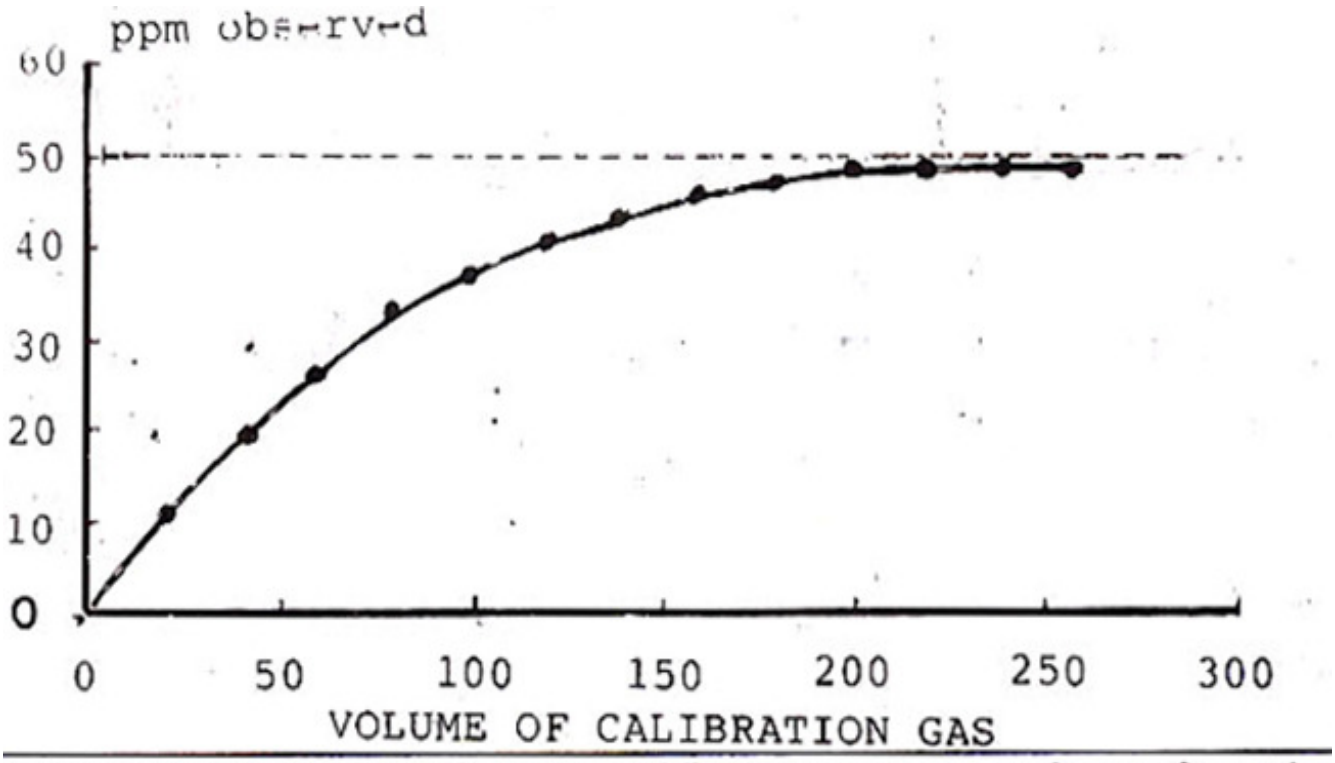

Figure 5. Values (ppm) of 50 ppm calibration gas versus volume of sample.

3. LInearity of dilution

This was confirmed by diluting different volumes of smoke from a hookah upto 200 ml. Almost complete linearity (correlation conffident = 0.95) was observed at dilutions from 1:0 to 1:10 [regression equation, Y= 5.7X (Figure 6)].

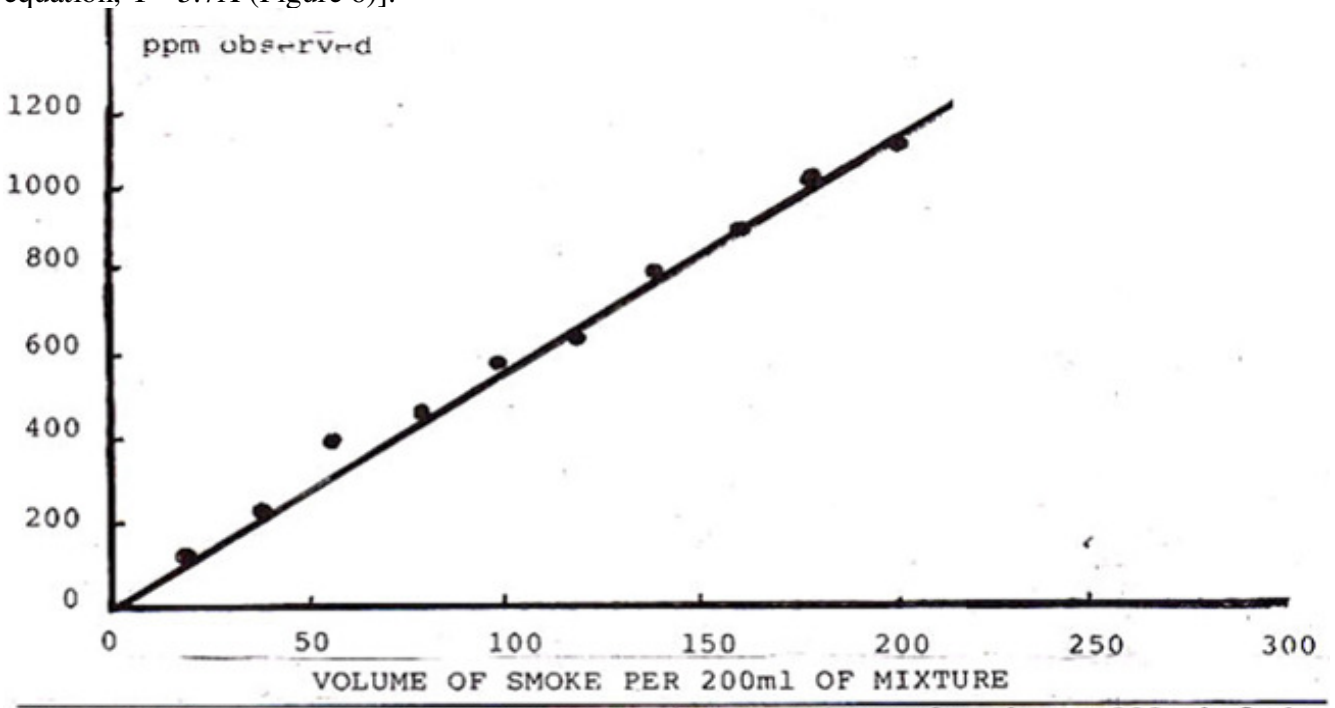

Figure 6. Linearity of dilution; ppm observed versus volume of smoke per 200 ml of mixture (smoke + ambient air).

We selected 1:10 as working sample dilution to protect sensor and battery of the equipment 20 ml of

smoke was diluted to 200 ml using air to take sample measurements. To check the effect of air dilution on CO concentration, 20 ml of 50 ppm calibration gas was diluted in air to 200 ml and pumped into the sampling system for measurement. Ten such measurements showed a mean level of 4.3±0.4 ppm. This when corrected for dilution gave 43±4 ppm (recovery 86%). The same procedure was adapted for measuring the values in samples. The observed gas fractions were finally corrected for recovery and dilution. Eight repeat measurements were taken for each category to find the mean value. Student's t-test was used to assess significance of the difference between the mean values.

Results

The CO fractions observed in smoke collected from two different sizes of hookah, using domestic charcoal and different varieties of tobacco are given in Table I. The values for Dera wala tobacco are significantly lower than the values for other varieties Of tobacco ($P < 0.05$). There is no significant difference between fractions of filtered and unfiltered smoke. The small sized hookah gave 3-4 times higher fractions ($P < 0.00\ 1$) of gas than large hookah.

Fractions obtained with commercial charcoal vary slightly with type of tobacco and there is no significant difference between fractions of filtered and unfiltered smoke (Table II). Levels are very high ($P < 0.001$) compared to the levels with domestic charcoal. CO fractions of smoke of different brands of cigarettes are given in Table Ill. The individual brands differ significantly in their fractions of CO. A comparison of hookah (usingdomestic charcoal) and cigarette smoke fractions shows that large size hookah gives lowest fractions of CO. Highest fractions are found in small size hookah and cigarettes are in the middle.

Discussion

Carbon monoxide, a colourless, odourless and poisonous gas and is produced at high temperatures by incomplete combustion of carbonaceous fuels in oxygen deficient atmosphere. These conditions prevail at the lighted end ofa cigarette and on the fire bowl of a hookah. The hazards of cigarette smoking have extensively been studied[2-9] and cigarette has been described as a principal cause of cancer[10]. Cardiac arrhythmia has also been reported in patients with coronary artery disease by elevated levels of carboxyhaemoglobin[11]. However, the incidence of lung cancer is low in sheesha smokers of Saudi Arabia[12]. although lung function is affected by increased percentages of COHb[13]. The sheesha is a device similar to the hookah in the subcontinent. The smoke passes first through water, nicotine and other water soluble hydrocarbons are dissolved (or condensed) and retained in the water (or on the wails of the smoking system). The low incidence of lung cancer among sheesha smokers might be related to the retention in water of these hydrocarbons, which may be carcinogenic. However, carboxyhaemoglobin (COHb) percentages in sheesha smokers are very high (8.8 ppm) as compared to cigarette smokers (6.1 ppm) and nonsmokers (1.7 ppm). Data on COHb percentages of sheesha smokers[14,15] is "state values". No such study has however been reported for hookah smokers. We have estimated carbon monoxide fractions in hookah and cigarette smoke to compare the CO hazards in these types of smoking. The observed fractions do not represent the actual fractions of smoke inhaled by smokers which may be as high as 5%[12], the most probable reason being relatively more supply of oxygen under high suction pressure in our situation. The observed fractions of CO show that carbon monoxide hazard is approximately the same with cigarette smoke as well as the hookah smoke. The use of commercial charcoal gives very high fractions. The U.K. Health and Safety Council (a U.K. government department) recommends only 50 ppm (0. 005%) for a period of 8 hour exposure or 400 ppm (0.04) per 15 minutes in an industrial environment for the safety of personnel[1]. In hookah

smoking the CO fractions can be reduced by increasing the size of device, i.e., fire bowl size, pipe length and proper selection of charcoal. Further, CO fractions of hookah smoke could be higher than those of cigarette (although the values could be comparable with the cigarette if hookah size is increased and proper charcoal is selected). The quality of tobacco also seems affecting CO levels, e.g., significantly low fractions are seen with Dera wala tobacco ($P< 0.05$). We conclude that CO levels are as high in hookah as in cigarette smoke. Both types of smoking have high risk of CO poisoning.

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