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ORIGINAL ARTICLE

Perchloroethylene and Trichloroethylene in the Air and Effluent of Dry Cleaning Shops

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ABSTRACT

The objective of this study was to evaluate the presence of perchloroethylene (PCE) and trichloroethylene (TCE) in dry cleaning shops in Tehran, Iran. PCE and TCE are two most prevalent solvents in dry-leaning shops. Air and effluent samples were collected in October to December 2011 from 10 dry-cleaning shops. Analyses were performed by head-space gas chromatography technique. Gas chromatography with FID detector is used for analysis. Mean PCE levels in the air of ten dry-cleanings ranged from 42.7 to 516 μgL^{-1} with maximum level of 960, PCE mean levels in the effluent ranged from 186.5 to 292.9 μgL^{-1} with maximum level of 326. Mean TCE levels in the air effluents ranged from 29.5 to 543.7 μgL^{-1} with maximum 964 and 25.5 to 29.75 μgL^{-1} with maximum level of 37 μgL^{-1} respectively. The survey of the PCE and TCE in dry-cleaning shops in Tehran shows that both air and effluent have been contaminated by PCE and TCE. These solvents have several negative health effects. Health education is essential for workers.

Keywords: *Trichloroethylene, Perchloroethylene, Dry Cleaning Shops, Air*

INTRODUCTION

Two special organochloro compounds, perchloroethylene and trichloroethylene are often used for dry cleaning solvents [1, 2]. Tetrachloroethylene (PCE or Perc) is a kind of sweet nonflammable colorless chemical with a stench that its odor threshold is 1 ppm [3]. TCE is a volatile, nonflammable and colorless liquid [4]. Tetrachloroethylene are widely used in industry as a solvent in dry-cleaning, as a degreasing agent for manufactured metal parts and as a precursor in the production of chlorofluorocarbons. Furthermore, they can play a role in designing and manufacturing of textiles, the production of paint removers and printing ink, and the formulation of adhesives, sealants, lubricants, typewriter correction fluids, polishing and specializing cleaning fluids. Tetrachloroethylene are included in consumer products such as motor vehicle cleaners, stain removers, adhesive and wood cleaners [5-7].

TCE can have several roles including extraction solvent, chemical intermediate and a major component of paints and coating, varnishes, paint strippers, adhesives, pesticide, lubricants and metal cleaners [8]. These solvents are source of indoor air pollution in the commercial dry- cleanings [9]. Exposure to PCE and TCE inhalation can cause unconsciousness, headaches,

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Table 1. Mean PCE and TCE concentration in the dry-cleaning shops air (sample size 4, total 48)

Station	PCE (µg/L)				TCE (µg/L)			
	Mean	Max	Min	SD	Mean	Max	Min	SD
Dry-cleaning no.1	64	81	38	18.5	54.57	65.3	45	9.65
Dry-cleaning no.2	120.7	135	112	10	49	58	40	8
Dry-cleaning no.3	516	960	320	298	543.75	964	336	285
Dry-cleaning no.4	47.2	68	22	19	56.17	74.7	45	13.36
Dry-cleaning no.5	52	82	30	22	51.7	59	45	6.39
Dry-cleaning no.6	55	79	27	22	55	65	50	6.78
Dry-cleaning no.7	42.7	54	35	8.38	33.25	36	30	2.75
Dry-cleaning no.8	59.2	77	42	15.1	29.5	35	25	4.2
Dry-cleaning no.9	80.5	94	58	15.7	37	45	30	6.27
Dry-cleaning no.10	71.25	89	59	12.7	47	52	41	4.96
Underground Air	30.5	37	25	5.4	113.5	143	99	20.53
Gas station Air	8.7	15	0	6.3	49.25	55	45	4.35
Total	95.68	960	0	151	93.3	964	25	156

Notes: $p<0.05$
Capacity all of dry-cleaning machine (kg):25

sleepiness, dizziness and adversely affect the liver and kidney [10, 11]. Other health effects of these compounds are considered as slight-irritation of mucosa, gastro- intestinal disturbances and the central nervous system malfunction [2]. Chronic exposure to PCE is accompanied by many severe toxicological and pathological problems. The toxic effects of PCE exposure are associated with disturbances in the central nervous system and changes in the parenchymal organs in the liver and kidneys [12]. Moreover, PCE exposure has also shown mutagenic and carcinogenic effects in some animals such as mice and rats [12]. Widespread use as well as improper handling and disposal, are the reasons why PCE is frequently detected in various media of environment such as groundwater, surface water, wastewater, air and food by various studies [13-17]. Therefore monitoring of these solvents to prevent of adverse health effects should be done.

The objective of this study was to evaluate the presence of trichloroethylene and perchloroethylene of dry-cleaning in Tehran.

MATERIALS AND METHODS

To determine PCE and TCE from air and effluent of dry-cleaning shops in Tehran, Iran, ten occupationally dry-cleaning shops were selected that used PCE as well as solvent. Air and effluent samples were collected in October to December 2011 from 10 dry-cleanings. Besides, four air samples were collected from gas

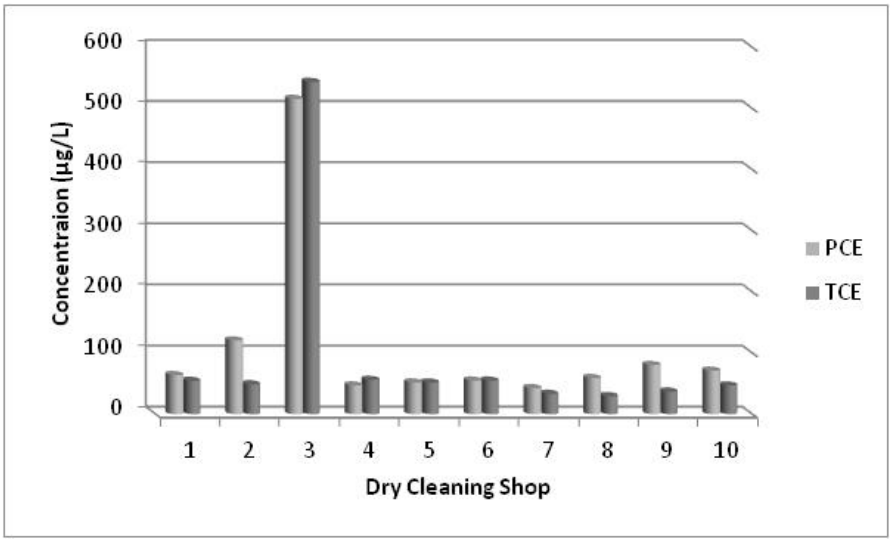

Fig 1. Mean PCE and TCE concentration in the dry-cleaning shops air

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Table 2. Mean PCE and TCE concentration in the effluents of dry cleaning shops (sample size 4, total 44)

Station	PCE (µg/L)				TCE (µg/L)			
	Mean	**Max**	**Min**	**SD**	**Mean**	**Max**	**Min**	**SD**
Dry-cleaning no.1	252.5	300	200	49.9	25.5	32	22	4.5
Dry-cleaning no.2	186.5	211	156	22.7	25.5	28	23	2.4
Dry-cleaning no.3	194.5	217	178	16.7	27.7	32	22	4.2
Dry-cleaning no.4	292.9	326	256	29.2	29.65	34.6	25	4.4
Dry-cleaning no.5	253.7	301	217	42.3	29	34	23	4.96
Dry-cleaning no.6	222.7	267	189	32.4	29	36	26	4.76
Dry-cleaning no.7	272	323	219	53	29.25	34	24	4.57
Dry-cleaning no.8	271.2	326	217	55.2	29.75	37	22	6.34
Dry-cleaning no.9	258	310	217	43.7	29	36	23	5.7
Dry-cleaning no.10	268.2	292	238	25.7	27.5	32	23	3.7
Tab water	11.75	15	10	2.36	0	0	0	0
Total	225.8	326	10	82.3	25.6	37	0	9.2

Notes: $p<0.05$

Capacity all of dry-cleaning machine (kg):25

station and underground and four water samples were collected from water distribution system that chlorinated. From each dry cleaning four samples were taken during the study, one sample in every 15 days. The air samples were taken by Tedlar bag with 3L volume and effluent samples were taken by 40 mL vials equipped with a screw cap with Teflon (TFE)-faced silicon septum that were used for sampling. Samples were stored in chilled condition (at 4ºC) and analyzed immediately after delivery to laboratory [18].

Analyses were performed by head-space gas chromatography technique. Concentrations of both PCE and TCE samples were determined through GC-FID analysis (VARIAN CP-3800, Australia). The gas chromatography was fitted with a CP-Sil 8 CB capillary column (30 m, 0.32 mm ID, 0.25 µm film thickness).For effluent samples the injector temperature was 150^{o}C; initial oven temperature was 35^{o}C (held for 1 min) and increased to 100^{o}C at a rate of 16^{o}C min^{-1}, held for 5 min. The inlet (200 µL) was operated in 20% split mode.

Helium (99.999%) was used as carrier gas at 1 mL min^{-1}. 200 µL air samples was injected by syringe manually.

The quality control practices including calibration, initial quality control, batch quality control (including reagent blank, laboratory-fortified blank, laboratory-fortified sample, internal and surrogate standard) were done according to standard methods (APHA 2005). The lowest detection level (MDL) for PCE and TCE analysis by GC with the above mentioned method was considered 5 µgL^{-1} with the same method.

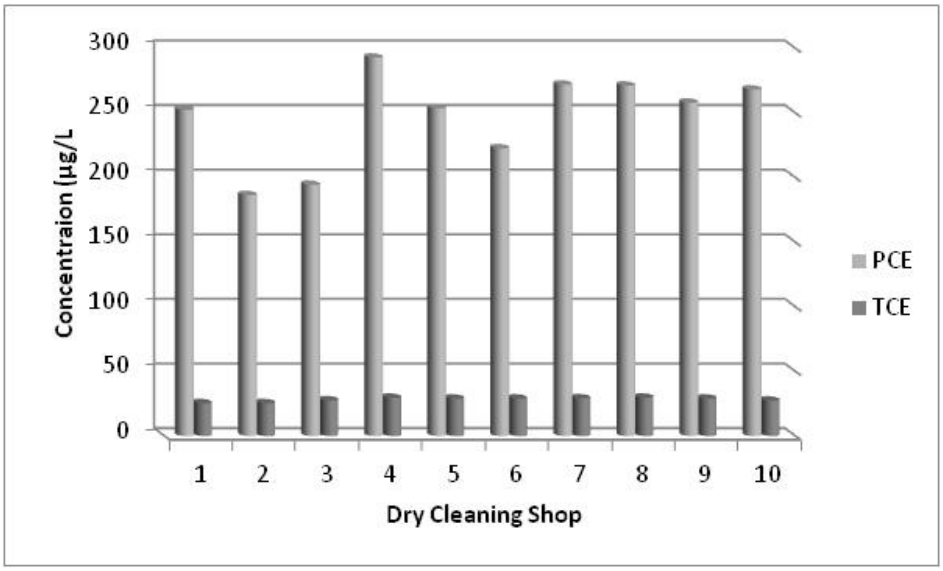

Fig 2. Mean PCE and TCE concentration in the effluents of dry cleaning shops

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RESULTS

The results of environmental measurements (µg/L) in the ten dry-cleaning shops are shown in Table 1 , 2 and Figs 1 & 2. The mean value for PCE levels in the air samples of ten dry-cleanings ranged from 42.7 to 516 μgL^{-1} with maximum level of 960 $\mu gL^{-1}$and mean levels in effluent ranged from 186.5 to 292.9 μgL^{-1} with maximum level of 326 μgL^{-1}. Mean TCE levels in the air effluents ranged from 29.5 to 543.7 μgL^{-1} with maximum 964 and 25.5 to 29.75 μgL^{-1} with maximum level of 37 μgL^{-1} respectively.

Results of this study showed that there was a significant difference between the PCE and TCE of the air and effluent samples from the ten dry-cleaning $p<0.05$. The PCE value of the air samples of most dry-cleanings except air of gas station and underground are more than TCE. Also PCE value in the effluents are more than TCE7 (Table 2 and Fig 2). PCE is detected in the chlorinated water distribution system but TCE is not detected. The main reason is that PCE can be used more than TCE by dry-cleaning. The highest amount of both PCE and TCE in the air of dry-cleaning number 3 is reported, where the dry cleaning machine is old and the lowest amount is observed in dry-cleaning number 7 (Table 1 and Fig 1).

DISCUSSION

WHO developed its air guideline based the LOAEL for kidney effects in dry-cleaning workers exposed 40 hours/week at 102 mg/m^3 for PCE. WHO converted this value into a continuous exposure value by dividing 102 mg/m^3 by a factor of 4.2 (168 hours/week divided by 40 hours/week). The outcome is further divided by an uncertainty factor of 100 to account for using LOAEL rather than NOAEL, and for intra species variation. The calculation makes a value of 0.25 mg/m^3. However, WHO chose to use 0.25 mg/m^3, derived from human data, as its air quality guideline [19]. Therefore the concentration of PCE in the dry cleaning shops higher than these guidelines.

PCE and TCE Levels in the most all dry cleaning shops effluents exceeded the EPA drinking water standard of 5 μgL^{-1} [20]. There are several reports that list the VOCs in various media sewage processing, air, surface water, ground water and soil in different places [12-17, 21]. The other testing concentration, 1 mg/L PCE, has been detected in groundwater from contaminated areas [22].

In occupational settings, exposure levels are higher. There are several reports that list the PCE in different places such as: Lauwerys et al. (1983) and Vyskocil et al. (1990) have demonstrated PCE in dry-cleaning shops mean time weighted average concentrations of about 157 mg/m^3 (range 10–800 mg/m^3) [23, 24]. In another study in the homes of dry-cleaning facility workers in Italy, it has been prove that exposure concentrations (8-hour averages) of 2.6–221.5 mg/m^3 [25]. Moreover, both PCE and TCE are detected in the water and wastewater of automobile factory in Iran [21].

According to the results of this study, the amounts of PCE and TCE are more than allowable limits in the air and effluent of dry-cleaning shops. The main reason of this problem can be the workers lack of knowledge about the rate of usage and method of solvent application that leads to negative effects. Thus, responsible directors and health officers are responsible for educating workers.

CONCLUSION

The survey of the PCE and TCE in dry-cleaning shops in Tehran shows that both air and effluent have been contaminated by PCE and TCE. These solvents have several negative health effects. Health education is essential for workers. To prevent environmental pollution and its negative health effects treatment processes are necessary for removing PCE and TCE. To prevent health effects, using both personal protective equipment (e.g. mask) and air conditioning in dry cleaning are crucial.

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