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Survey of Hazardous Organic Compounds in the Groundwater, Air and Wastewater Effluents Near the Tehran Automobile Industry

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Abstract Potential of wastewater treatment in car industry and groundwater contamination by volatile organic compounds include perchloroethylene (PCE), trichloroethylene (TCE) and dichloromethane (DCM) near car industry was conducted in this study. Samples were collected in September through December 2011 from automobile industry. Head-space Gas chromatography with FID detector is used for analysis. Mean PCE levels in groundwater ranged from 0 to 63.56 $\mu g\ L^{-1}$ with maximum level of 89.1 $\mu g\ L^{-1}$. Mean TCE from 0 to 76.63 $\mu g\ L^{-1}$ with maximum level of 112 $\mu g\ L^{-1}$. Due to the data obtained from pre treatment of car staining site and conventional wastewater treatment in car factory, the most of TCE, PCE and DCM removed by pre aeration. Therefor this materials entry from liquid phase to air phase and by precipitation leak out to the groundwater. As a consequence these pollutants have a many negative health effect on the workers by air and groundwater.

Keywords Trichloroethylene · Perchloroethylene · Dichloromethane · Car industry

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Hazardous chemicals in the industrial wastewater may be leak out to the groundwater resources (Dobaradaran et al. 2010). One group this material is volatile halogenated organic compounds (VOCs). These materials can enter the groundwater water and affect human health in this way (Lopes and Bender 1998; Campillo et al. 2004). The examples of these compounds are perchloroethylene (PCE), trichloroethylene (TCE) and dichloromethane that used very high in industry. Tetrachloroethylene (PCE or Perc) is a volatile organic compound, colorless chemical, non-flammable, and sweet with a stench that is the odor threshold is 1 ppm (ATSDR 1997). Trichloroethylene is a non-flammable, volatile and colorless liquid (Gist and Burg 1995). The major industrial uses of tetrachloroethylene are as a solvent in dry-cleaning, as a degreasing agent for manufactured metal parts and as a precursor in the production of chlorofluorocarbons.

Trichloroethylene has many different uses such as extraction solvent, chemical intermediate and as a component in paints and coating, varnishes, paint strippers, adhesives, pesticide, lubricants and metal cleaners (ATSDR 1997). As a consequence of this widespread use, it is commonly detected as an environmental contaminant of groundwater, surface water, soil and air (Lopes and Bender 1998).

Dichloromethane (DCM) is a volatile organic compound, colorless liquid with a moderately sweet aroma. Dichloromethane is widely used as solvent in paint removers, aerosol propellant, degreaser agent, depressant and in the manufacture of foam polymer (Poli et al. 2005).

Exposure of PCE and TCE inhalation can cause unconsciousness, headache, sleepiness, confusion and adversely affect the liver and kidney (Philip et al. 2007; Harendra and Vipulanandan 2011). Other health effect of these compound are slight-irritation of mucosa, gastro-intestinal disturbances, central nervous system malfunctions (Rastkari et al. 2011). 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 (Lash and Parker 2001). Also PCE exposure has also shown mutagenic and carcinogenic effects in some animals such as mice and rats (Lash and Parker 2001). Dichloromethane has a harmful effect to human health such as reversible central nervous system, narcosis, irritation eyes, respiratory tract and lung edema (poli et al. 2005). The objective of this study was assessment of wastewater treatment in car industry, groundwater and air contamination by (PCE), (TCE) and other volatile organic compounds VOCs (such as dichloromethane) near car industry.

Materials and Methods

The car factory is located in the Tehran-Karaj highway, West of Tehran. There are ten groundwater wells in the factory site which all of them were selected as sampling points. The sampling was done in 4 months from September through December 2011. From each groundwater well, water treatment plant, pretreatment wastewater of car staining site, wastewater treatment plant and air of car staining site four samples were taken during the study, a sample in each 30 days. 40 mL vials equipped with a screw cap with Teflon (TFE)-faced silicon septum were used for sampling of water and wastewater. Samples were stored in chilled condition (at 4°C) and analyzed immediately after delivery to laboratory (APHA 2005). The air samples were taken by tedlar bag with 3 liter volume.

Analyses were performed by head-space gas chromatography. Perchloroethylene, TCE and DCM concentration of samples were determined as below: GC-FID analysis with a VARIAN CP-3800 (Australia) was used to determine TCE and PCE concentration of samples. The GC was fitted with a CP-Sil 8 CB Capillary Column (30 m, 0.32 mm id, 0.25 μm film thickness). For effluent sample injector temperature was 150°C, initial oven temperature was 35°C (held for 1 min) and increased to 100°C at a rate of 16°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}. For air samples 200 μl 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 minimum detection level (MDL) for PCE, TCE and DCM analysis by GC with above method was ≤ 5 μg L^{-1}.

Results and Discussion

The obtained results as mean of measured parameters include PCE, TCE and DCM in the groundwater well, water treatment plant, pretreatment wastewater of car staining site, wastewater treatment plant and air of car staining site are presented in Tables 1, 2, 3 and 4.

The pre-treatment wastewater of car staining site consists of pre aeration, flotation (DAF), coagulation and

Table 1 Mean PCE and TCE concentration in the pretreatment and wastewater treatment plant

Station	Sample size (n)	PCE (mg L^{-1})				TCE (mg L^{-1})			
		Mean	Max	Min	SD	Mean	Max	Min	SD
Pretreatment[a]	4	39.37	43.2	32.4	4.76	34.94	39.12	28.92	4.3
Pretreatment[b]	4	11.9	13.5	10.4	1.31	36.19	38.9	33.32	2.4
Pretreatment[c]	4	15.67	17.4	13.34	1.7	30.2	33.2	27.15	2.57
Pretreatment[d]	4	1.72	2.12	1.32	0.34	30.49	33.36	25.3	3.7
Influent wastewater	4	4.48	5.6	2.33	1.48	18.87	26.7	7.91	8.97
Coagulation Effluent	4	0.129	0.17	0.06	0.05	3.71	4.8	2.33	1.08
Biological effluent	4	0.043	0.07	0.03	0.03	0.11	0.15	0	0.07
Disinfection Effluent	4	0.061	0.09	0.03	0.02	1.47	2.21	0.08	0.96
Air of car staining site	4	0.44	0.56	0.36	0.09	0.2	0.26	0.16	0.04
Total	36	8.2	43.1	.00	12.5	17.3	39.12	00	15.6

[a] Influent of lining (line1)

[b] Influent of line 2

[c] Aeration tank

[d] Effluent of pretreatment car staining site

Table 2 Mean PCE and TCE concentration in the well and water treatment plant

Station	Sample size (n)	PCE(μg/L)				TCE(μg/L)			
		Mean	Max	Min	SD	Mean	Max	Min	SD
Well 1–3	12	0	0	0	0	0	0	0	0
Well 4	4	39.3	56.2	0	26.3	76.63	112	0	53.2
Well 5	4	43.7	67.1	0	29.6	22.5	52	0	26.6
Well 6	4	30.37	50.2	0	21.9	13.25	29	0	15.4
Well 7	4	56.67	80.9	0	38	20	45.32	0	23.49
Well 8	4	26.75	45	0	19.2	13	29	0	15.2
Well 9	4	63.56	89.1	0	42.6	20	47	0	23.8
Well 10	4	15.7	24.6	0	11.2	7.25	17	0	8.6
Mixed of all well	4	24.7	36.2	0	16.6	11.5	28	0	13.9
Influent of Karaj reservoir	4	54.27	78.1	0	36.6	9.5	23	0	11.4
Influent[a]	4	16.86	28.2	0	12.5	7	16	0	8.24
Effluent[b]	4	0	0	0	0	47.88	67.19	0	32
Total	56	26.5	89.1	0	29.8	17.96	112	0	28.4

[a] Influent water treatment plant

[b] Effluent water treatment plant

Table 3 Mean DCM concentration in the pretreatment and wastewater treatment plant

Station	Sample size (n)	DCM(μg/L)			
		Mean	Max	Min	SD
Pretreatment[a]	4	43.6	50	30	6.8
Pretreatment[b]	4	248	280	220	25
Pretreatment[c]	4	272	330	240	40
Pretreatment[d]	4	270	320	210	45
Influent wastewater	4	130	210	40	80
Coagulation Effluent	4	120	180	30	60
Biological effluent	4	0	0	0	0
Disinfection Effluent	4	0	0	0	0
Air of car staining site	4	54	60	50	30
Total	36	127	33	.00	11.3

[a] Influent of lining(line 1)

[b] Influent of line2

[c] Aeration tank

[d] Effluent of pretreatment staining car site

Table 4 Mean DCM concentration in the well and water treatment plant

Station	Sample size(n)	DCM(μg/L)			
		Mean	Max	Min	SD
Well 1-4	16	0	0	0	0
Well 5	4	133.8	200	0	91
Well 6	4	42.8	80	0	35
Well 7	4	105	150	0	70
Well 8	4	0	0	0	0
Well 9	4	129	210	0	92
Well 10	4	43.7	80	0	33
Mixed of all well	4	461	510	410	44
Influent of Karaj reservoir	4	0	0	0	0
Influent[a]	4	0	0	0	0
Effluent[b]	4	133	170	100	29
Total	56	75	510	0	127

[a] Influent water treatment plant

[b] Effluent water treatment plant

flocculation. The wastewater treatment plant in factory consists of screening, primary sedimentation, equalization tank, pre aeration, coagulation and flocculation (DAF system), activated sludge, clarifier, sand filtration and chlorination. The collected wastewater from car industry process enters wastewater treatment plant in the factory.

Tables 1 and 3 shows that concentration of PCE and TCE in the pretreatment wastewater of car staining and wastewater treatment plant more than the DCM. But concentration of DCM in the groundwater well and mixed water from different well is more than the PCE and TCE. This is due to higher solubility of DCM related to PCE and TCE. The mean concentration of PCE, TCE and DCM in pretreatment wastewater of car staining was found to vary widely from 1.72 to 39.37 mg L^{-1}, 30.49 to 36.19 mg L^{-1} and 43.6 to 272 μg L^{-1} respectively and influent of lining contained max PCE and TCE concentration and aeration tank contained max DCM concentration with 43.2, 39.12 mg L^{-1} and 330 $\mu g\ L^{-1}$ respectively. The mean concentration of PCE, TCE and DCM in wastewater treatment plant was found to vary widely from 0.043 to 4.48 mg L^{-1}, 0.11 to 18.87 mg L^{-1} and 0 to 130 $\mu g\ L^{-1}$ respectively and influent of wastewater contained max PCE, TCE and DCM concentration with 5.6, 26.7 mg L^{-1} and 210 $\mu g\ L^{-1}$ respectively. The mean concentration of PCE, TCE and DCM in the air of car staining site was found 440, 200 and 54 $\mu g\ L^{-1}$ respectively with max level of these compound concentration were 560, 260 and 60 $\mu g\ L^{-1}$ respectively.

The mean concentration of PCE, TCE and DCM in water treatment plant and ground water were found to vary from 0 to 63.56 $\mu g\ L^{-1}$, 0 to 76.63 $\mu g\ L^{-1}$ and 0 to 461 $\mu g\ L^{-1}$ respectively and well no.9 contained max PCE, well no.4 contained max TCE and mixed well contained max DCM concentration with 89.1, 112 and 510 $\mu g\ L^{-1}$ respectively. Perchloroethylene, TCE and DCM Levels in the most wells and wastewater treatment plant exceeded the EPA drinking water standard of 5 $\mu g\ L^{-1}$ (US Environmental Protection Agency 2003). There are several reports that list the VOCs in various media sewage processing, air, surface water, ground water and soil in different places (Lopes and Bender 1998; Albergaria et al. 2010; Dobaradaran et al. 2010). The other testing concentration, 1 mg L^{-1} PCE, has been detected in groundwater from contaminated areas (Leschber et al. 1990).

The effluent of treated wastewater plant is used as irrigation water for plants and green land in factory site and the main portion of treated wastewater is discharged into the absorbing wells. The groundwater in absorbing wells with higher hydraulic head moves toward wells with lower hydraulic heads. Also result show that the amount of detectable PCE, TCE and DCM in the groundwater samples of wells increased with cold weather and precipitation. As it is seen in Tables 2 and 4 wells waters were contaminated by these contaminated groundwater flows. Because the density of these compound are heavier than water, it is likely that these compound move downward through subsurface until lower permeability layer, a density difference of about 1 % with water can mainly influence the contaminant movement in saturated and unsaturated areas (Josephson 1983; Dobaradaran et al. 2010).

According to the results of this study the amounts of PCE, TCE and DCM were more than allowed limits in the air, groundwater and wastewater treatment plant of car factory. The use of this water and respiration of air of the staining site can cause specific health problems especially for workers exposed occupationally. Educating of workers is the first things to do by the responsible directors and health officers.

The survey of the PCE, TCE and DCM in car industry in Iran showed that air, effluent of wastewater treatment and groundwater have been contaminated by these compound. Due to the data obtained from pre-treatment of car staining site and conventional wastewater treatment in car factory, the most of TCE, PCE and DCM removed by pre aeration. Therefor this materials entry from liquid phase to air phase and by precipitation leak out to the groundwater. As a consequence these pollutants have a many negative health effect on the workers by air and groundwater. These solvents have a many negative health effect. Health education is necessary so workers. To prevent contamination of environment and negative health effect treatment processes is necessary to removal PCE, TCE and DCM. The wells water in car factory needs advanced treatment processes for removal VOC. To achieve the PCE, TCE and DCM standard it is recommended advanced treatment with proper technologies like adsorption with activated carbon, air stripping or in well aeration, bioremediation and advanced oxidation processes include ultrasonic, ultraviolet ray, ozone and hydrogen peroxide (Dobaradaran et al. 2010). To prevent health effects on the use of personal protective equipment (e.g. mask) and air conditioning in the air of car staining site is necessary.

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