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Survey of Emitted Benzene, Toluene and 2-propanol in Air Ambient of the Copper Industrial in Iran

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ABSTRACT

The aim of the present study was to provide a useful data on management of air pollution in the Copper industry. An Anasorb CSC (Coconut shell charcoal 150 mg) tube was used to sample Toluene, 2-Propanol and Benzene in ambient air of the Sar-Cheshmeh Copper Complex. Samples were desorbed by carbon disulfide and analyzed with gas chromatography-mass spectrometry. Samples (personal and environmental) were obtained from 4 locations in The Unit Concentrator at date Jan. to Feb. 2010 with use of method National Institute for Occupational Safety and Health (NIOSH), number 1400 and 1501. A total of 30 hydrocarbons were identified in the ambient air of The Unit Concentrator (Sar-Cheshmeh Copper Complex). The mean concentrations sampling environmental for Toluene, 2-Propanol and Benzene were 0.00058, 3.18 and 0.761 ppm, respectively, such as, sampling personal for Toluene, 2-Propanol and Benzene were 0.0726, 0.342 and 0.0188 ppm, respectively. The present research showed that relation between TLVs (Benzene; 0.5 ppm) by concentration Benzene in the ambient air was significantly different (p-value<0.05). The results were shown that mean concentration of Benzene was more than standard level and system need to be controlled for prevention of pollution in ambient air.

Key words: 2-propanol, benzene, toluene, sar-cheshmeh copper complex, gas chromatography

INTRODUCTION

Sar-cheshmeh is a large open cast copper mine in the Kerman Province of Iran, considered to be the second largest copper deposit worldwide (Vatani *et al*., 2010). Also, It has been contained substantial amounts of molybdenum, gold and other trace metals, The Sar-Cheshmeh Copper Complex is located of 160 km southwest of Kerman city and 50 km south of Rafsanjan city. The Sar-cheshmeh bodies, situated in the central part of Zagros ranges, consist of folded and faulted early tertiary volcano-sedimentary rocks, Production units of Sar-Cheshmeh Copper Complex

involve the mine itself, Unit Concentrator, smelter, refinery, foundries and leaching (Vatani *et al.*, 2010). The Volatile Organic Compounds are the most important air pollution sources inside buildings and one of the considerable reasons for the building syndrome (Chan *et al.*, 2007; Bernstein *et al.*, 2008), Volatile Organic Compounds (i.e., Benzene, Toluene, p-Xylene, m-Xylene, Ethyl benzene (BTEX) or air toxics are emitted or formed from a wide range of sources including motor vehicles, wood heaters, incinerators, bushfires, cigarette smoke, paints, solvents and dry cleaning (Hinwood and Di Marco, 2002; Xu *et al.*, 2008; Bernstein *et al.*, 2008), Long term Exposure to Volatile Organic Compounds (i.e., BTEX) predisposes to bladder cancer, leukemia, nervous system damage and air way ophthalmic mucosal inflammation (Blount *et al.*, 2006; Ribes *et al.*, 2007; Wichmann *et al.*, 2009). Previous studies have shown higher levels of Polyaromatic Hydrocarbons (PAHs) and VOCs in the regions next to petrochemical plants than in other parts of the city. Furthermore, The concentrations of aromatic compounds, such as benzene and toluene, were much higher in the industrial region (Wichmann *et al.*, 2009). BTEX are important parameters to evaluate the quality of air inside and outside of work and living environment, There are various methods to evaluate and estimate the effects of harmful exposure with Volatile Organic Compounds, including measurement of Benzene, Toluene, p-Xylene, m-Xylene, Ethyl benzene and their Metabolite in breathing air, blood and urine (Blount *et al.*, 2006). Research of, shown that is on a campus academic, 37 air pollutants exist for example benzene, toluene and 2-Propanol (Chan *et al.*, 2007). Study of Parra *et al.* (2009) in a medium size city in the Northern Spain, shown that mean concentrations of benzene and toluene were 2.84 and 13.26 μg m^{-3}, respectively. Also, research Kong-Hwa Chiu in a semiconductor industrial park in Taiwan, shown that The major components measured in the ambient air are 2-propanol (29-135 ppb), benzene (0.7-1.7 ppb) and toluene (13-20 ppb) (Pekey and Arslanbas, 2008). Research of Rao *et al.* (2005), shown that were emitted in the highest amounts air pollutants in a Petroleum Refinery. Aromatic hydrocarbons (for example: Benzene, Toluene and 2-Propanol) were emitted in the highest amounts in poultry litter composting process (Turan *et al.*, 2007).

Given the importance of air quality to the health and safety conditions in the Sar-Cheshmeh Copper Complex and potential effect caused by hydrocarbons, the goal of this study was to measure and evaluate of emitted Benzene, Toluene and 2-Propanol in air ambient of the Copper industrial in center of Iran.

MATERIALS AND METHODS

The equipments that have been used for measurement were include of pump (flow rate 100-200 mL min^{-1}), tube charcoal active (150 mg), a gas chromatograph-Mass spectrometry and a gas chromatograph-Flame Ionization Detector. This research was carry out in 4 locations sample environmental and 39 sample personal at Sar-Cheshmeh Copper Complex unit concentrator including; 1-between one and two Mill, 2-between four and five Mill, 3-Flotation Cells - Box Divider and 4-Room injection Chemical. We established a program of work at date Jan to Feb 2010, Sampling and analysis were carrying out by method number of 1400 and 1501 National Institute for Occupational Safety and Health (NIOSH) and Environmental Protection Agency (EPA) (NIOSH, 1994; Woolfenden, 1999). A Anasorb CSC (Coconut shell charcoal 150mg) absorption tube (SKC Company, USA) connected to a flow small pump (SKC Company, USA) was used for sampling air, The pump was operated at 200 mL/min and the sample duration was 100-120 min. The sampling obtains at the height of 1.2-1.5 m above ground factory level. Samples were extracted

with Carbon disulfides (CS_2) from the charcoal, Gas Chromatograph-Mass Spectrometry (GC) Agilent Technology, Model HP 6890 and spectrometer (MS), Model HP 5973 Network Mass Selective Detector). The separation of the compounds was used for achieved with capillary column HP-5 msec, 60 m×0.25 mm, 0.25 μm film thickness. Programmed this column has a temperature of 50°C for 5 min followed by an increase to 200°C at a rate of 10°C min^{-1} and finally, during analysis a constant temperature of 200°C for 10 min.

Statistical analysis: Collected data has been analyzed under SPSS 15 software and using One-sample t-test to compare concentration environmental and personal sampling air Benzene, Toluene and 2-propanol by the threshold level recommended (TLV) by the American Conference of Governmental Industrial Hygienists (ACGIH).

RESULTS

Hydrocarbons recognized in air unit concentrator: Table 1 was showed the 30 hydrocarbons recognized in the ambient air of Unit Concentrator (Sar-Cheshmeh Copper Complex) most of hydrocarbons are volatile and semi-volatile.

Table 1: Hydrocarbons Recognized in air Unit Concentrator

No.	RT* (min)	Compound
1	1.477	2-Propanol
2	1.927	Benzene
3	2.034	3-Methylhexane
4	2.165	Heptane
5	2.328	Methylcyclohexane
6	2.395	Ethylcyclopentane
7	2.579	Toluene
8	2.956	Octane
9	3.274	2,6-Dimethylheptane
10	3.367	1,1,3-Trimethylcyclohexane
11	4.116	Nonane
12	4.51	Propylcyclohexane
13	4.67	Alpha-Pinene
14	4.761	Camphene
15	5.009	4-Methylnonane
16	5.103	3-Methylnonane
17	5.518	Decane
18	5.604	Isocineole
19	5.671	Alpha-Terpinene
20	5.716	p-Cymene
21	5.964	Butylcyclohexane
22	6.418	2-Methyldecane
23	6.72	Alpha-Terpinolene
24	7.127	2-Methyldecalin
25	8.455	Dodecane
26	8.677	2,6-Dimethylundecane
27	8.805	2-Butyl-1,1,3-Trimethylcyclohexane
28	9.859	Tridecane
29	10.928	2,6,10- Trimethyldodecane
30	11.204	Tetradecane

*Retention time

In this study the low-retention time is for 2-propanol (1.477 min) and high-retention time is for tetradecane (11.204 min).

Concentration of 2-propanol, benzene and toluene in air sampling unit concentrator (Sar-cheshmeh copper complex): Table 2 showed that the average total concentration environmental sampling were 0.761±0.466, 0.0726±0.0341 and 3.181±0.942 ppm for Benzene, Toluene and 2-Propanol, respectively. Such as, the average total concentration personal samplings were 0.0188±0.00717, 0.0025±0.0025 and 0.342±0.124 ppm for Benzene, Toluene and 2-Propanol, respectively.

For both personal and environmental sampling 2-propanol had the higher concentrations in the air of the concentrator unit (significantly different, p-value<0.05).

This study showed that environmental samples concentration of the Benzene, Toluene and 2-Propanol were statistical correlations between benzene concentration and other hydrocarbons pollutants (Toluene and 2-Propanol) are consistent with the basic sources for emission pollutants in concentrator Unit (i.e., raw material and system productive). significantly higher than the personal samples in concentrator unit (Sar-Cheshmeh Copper Complex), such as, concentration Benzene in Area between four and five Mill of concentrator unit were higher than those the

Table 2: Concentration of 2-propanol, benzene and toluene in air sampling unit concentrator (Sar-Cheshmeh Copper Complex)

VOCs	Kinds samples	Between one and two Mill	Between four and five Mill	Flotation cell and Box Divider	Room injection chemical	Total samples	TLV* (ppM)
Benzene (ppm)	Environmental						0.5
	N.	7	9	7	8	31	
	$\bar{X} \pm SE$	0.483±0.201	2.08±1.57**	0.0514±0.0219	0.1413±0.068	0.761±0.466**	
	Range	0.03-1.44	0.09-14.53	0-0.16	0-0.54	0-14.53	
	Personal						
	N.	5	4	4	4	17	
	$\bar{X} \pm SE$	0.03±0.0148	0.0275±0.0214	0.0025±0.0025	0.0125±0.0125	0.0188±0.00717	
	Range	0-0.08	0-0.09	0-0.01	0-0.05	0-0.09	
Toluene (ppm)	Environmental						20
	N.	-	9	-	8	17	
	$\bar{X} \pm SE$	-	0.1844±0.09	-	0.0737±0.0737	0.0726±0.0341	
	Range	-	0-0.85	-	0-0.59	0-0.85	
	Personal						
	N.	-	-	-	4	4	
	$\bar{X} \pm SE$	-	-	-	0.0025±0.0025	0.0025±0.0025	
	Range	-	-	-	0-0.01	0-0.01	
2-Propanol (ppm)	Environmental						200
	N.	7	9	7	8	31	
	$\bar{X} \pm SE$	3.03±2.21***	8.12±1.95***	0.1764±0.114***	0.383±0.168***	3.181±0.942***	
	Range	0-15.64	0-14.39	0-0.82	0-1.29	0-15.64	
	Personal						200
	N.	5	4	4	4	17	
	$\bar{X} \pm SE$	0.23±0.113***	0.71±0.368***	0.0975±0.0878***	0.36±0.34***	0.342±0.124***	
	Range	0.03-0.67	0.02-1.39	0-0.36	0-1.38	0-1.39	

* Threshold level value. **Concentration benzene in area between four and five mill of concentrator unit and total samples were higher Than (Significantly deferent, p-value<0.05). Those the threshold level recommended by acgih. ***For both personal and environmental sampling 2-propanal had the higher(significantly different, p-value<0.05) concentrations in the air of the concentrator unit

threshold level recommended by The American Conference of Governmental Industrial Hygienists, ACGIH (significantly different, p-value<0.05). The results of a statistical analysis of the data for all samples (Table 2) indicate that emissions of individual pollutants in area of between four and five Mill is great than those in other area concentrator unit (Sar-Cheshmeh Copper Complex). This study found that Benzene did have significantly correlation with Toluene in the environmental samples and with 2-Propanol in the personal samples (p-value<0.05).

DISCUSSION

Thirty Hydrocarbons, including volatile and semi-Volatile Organic Compounds were recognized in the ambient air of Concentrator Unit. This study evaluated the personal and environmental exposure to benzene, toluene and 2-propanol in Concentrator Unit, Sar-Cheshmeh Copper Complex. The 2-propanol has higher concentration, while toluene has lower concentration among the selected volatile organic pollutants. although concentration of 2-Propanol and Toluene was lower than TLV but benzene concentration in the ambient air was higher than the threshold level recommended by The American Conference of Governmental Industrial Hygienists, ACGIH (significantly different, p-value<0.05). This study indicates that industrial emission specially in copper industry seems to be the most common sources of benzene, toluene and 2-propanol (VOCs) in Environment. This results has supported by some studies such as Bahrami (2001), Vatani *et al.* (2010), Atari and Luginaah (2009), Serrano-Trespalacios *et al.* (2004), Chan *et al.* (2007), Hippelein (2004) and Balanay and Lungu (2009). Significant correlation was found between personal and environmental samples in concentration of benzene, toluene and 2-propanol in this research and other studies Balanay and Lungu (2009) in Philippines; Pekey and Arslanbas (2008) in Turkey. The environmental sampling is not appropriate to estimate the exposure of worker (for example, Sar-Cheshmeh Copper Complex) to Benzene, Toluene and 2-Propanol because it underestimates these exposures (Pekey and Arslanbas, 2008; Balanay and Lungu, 2009).

In this study the concentration of Benzene, Toluene and 2-Propanolwas higher than study in a semiconductor industrial (Chiu *et al.*, 2005) and less than study in a Poultry Litter Composting Process (Turan *et al.*, 2007). Aromatic hydrocarbons (Benzene, Toluene and 2-Propanol) were emitted in the highest amounts in a Poultry Litter Composting Process (Turan *et al.*, 2007), in a petroleum refinery (Rao *et al.*, 2005) and in dyeing industrial (Jo *et al.*, 2004) that are similar to our results. The high level of pollutants can have worth effects on the blood system and central nervous system, such as, leukemia, bladder cancer, nervous system damage in the workers of concentrator unit, Sar-Cheshmeh Copper Complex (Bahrami, 2001; Ribes *et al.*, 2007; Blount *et al.*, 2006).

CONCLUSION

The copper industry is one of the most important source for aromatic pollution such as, Benzene, Toluene and 2-Propanol. The R and D office (Research and development) of Sar-Cheshmeh Copper Complex need to provide a systematic program for identification and control of emission assessment and monitoring of disease in workers.

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