

## Determination of Aluminum, Copper and Lead in Aleppo Company of Cable Industry (Syria) Using Industrial TSP, PM<sub>10</sub> and Chemical Trap Methods

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Determination of Al, Cu and Pb in Aleppo Company of cable industry (Syria) using total suspended particles (TSP) and PM<sub>10</sub> of aerodynamics particle sizes larger 0.3  $\mu\text{m}$  and chemical trap (CT) for total elements in air were studied. Al, Cu and Pb contents in working atmosphere with TSP, PM<sub>10</sub> and CT in different sections were measured by atomic absorption spectroscopy. The mean TSP and PM<sub>10</sub> levels were at 805.8 to 1130.2 and 264.5 to 350.2  $\mu\text{g}/\text{m}^3$ , respectively. Air Al, Cu and Pb concentrations were at 2.67 to 85.2 and 0.23 to 6.55; 3.8 to 228.7 and 0.27 to 16.84; 0.21 to 77.5 and 0.17 to 32.62  $\mu\text{g}/\text{m}^3$  using TSP and PM<sub>10</sub>, respectively, (Al, Cu and Pb in TSP and PM<sub>10</sub> were at 0.326 to 10.46 and 0.087 to 2.54 %; 0.46 to 20.24 and 0.10 to 6.58 %; 0.039 to 9.47 and 0.059 to 12.33 %, respectively). The total mean air Al, Cu and Pb pollutants using Chemical Trap (CT) were at 3.02 to 94.2, 4.1 to 242.0 and 0.28 to 152.0  $\mu\text{g}/\text{m}^3$ , respectively. The results showed that, the values of TSP, PM<sub>10</sub>, Al and Cu in working atmosphere much lower than the guideline values specified by the Occupational Safety and Health Administration (OSHA), while high levels of lead were more than the recommended maximum by OSHA; due to the fact that lead acid batteries and liquid gases plant adjacent to this factory from the western side and the wind direction often from west to east.

**Key Words:** Aluminum, Copper, Lead, Industrial particulates (TSP and PM<sub>10</sub>).

### INTRODUCTION

The concentrations of total suspended particles (TSP) and airborne particulate trace metals in seven districts of the Baixada Fluminense, a region of the Metropolitan area of Rio de Janeiro, where the pollution sources are local industries, vehicular emissions and natural inputs were studied<sup>1</sup>. The TSP levels were determined by gravimetry and the metals by inductively coupled plasma optical emission spectroscopy (ICP-OES). Geometrical means between  $55.47 \pm 15.9$  and  $241.57 \pm 40.0 \mu\text{g}/\text{m}^3$  were determined for TSP. Zn, Cu and Cd levels are high in comparison with other urban and industrial areas. Mean concentrations of Zn, Cu and Cd are 1.1-88 times, 2.9-60.9 times and 3.0-130.0 times higher than reported values for other industrial areas, respectively<sup>1</sup>.

In a paper<sup>2</sup> results for the industrial area of Santa Cruz in the city of Rio de Janeiro, Brazil, were reported. The measured concentrations of airborne particulate trace metals were up to 580 times higher than values for other urban and industrial areas, representing a potential hazard to the local population. Results for the downtown area of Rio de Janeiro<sup>3</sup> showed that the geometrical mean for total suspended particles (TSP) is higher than the Brazilian standards but the metal concentrations in airborne particulate matter are similar to the typical values of other urban regions.

Lead is one of the toxic elements and an environmental and occupational pollutant. The primary routes of lead exposure are ingestion and inhalation<sup>4</sup> and adults are primarily exposed to it through their occupation through inhalation<sup>5</sup>.

Total suspended particulate (TSP), copper, lead and aluminum concentrations in the workplace by the Occupational Safety and Health Administration (OSHA) must be lower than (5000, 1000, 50 and 1000  $\mu\text{g}/\text{m}^3$ , respectively)<sup>6</sup>.

Some metallic elements in ambient air particulates were determined in Taichung Airport (Taiwan), Hong Kong, Los Angeles, southeast China, Athens (Greece) and Oxford<sup>7-13</sup>.

This work is focused on the environment of air aluminum, copper and lead in Aleppo company of cable industry, Syria using total suspended particulates (TSP), inhaled particulates ( $\text{PM}_{10}$ ) of aerodynamics particle sizes larger  $0.3 \mu\text{m}$  and chemical trap (CT). Aluminum, copper and lead contents in working atmosphere with TSP,  $\text{PM}_{10}$  and CT in different sections were measured by atomic absorption spectroscopy.

## EXPERIMENTAL

A study comprising environmental was undertaken in the Aleppo company of cable industry, Syria, to ascertain the concentration of Al, Cu and Pb pollutants in various sections using TSP,  $\text{PM}_{10}$  and CT. The different investigated sections were the Al drawing, Cu drawing, Al stranding, Cu stranding, Packing and administration sections.

A high flow air sampler TSP (HVAS, Instrument NO. AS-16, USA) and TE-6070 high volume MFC  $\text{PM}_{10}$  MFC monitor reference method (TISCH Environmental, INC. 145 MIAMI AVE USA) were used to collect samples for 8 working hours in every section of plant using a glass filter Whatman EPM 2000 High-Volume 1882-866 and Micro-Quartz filter media  $8" \times 10"$  for TSP and  $\text{PM}_{10}$  respectively. Another samples were collected in chemical trap (CT)<sup>14</sup>, by bubbling working atmosphere in solution content 5 M of  $\text{HNO}_3$  and  $\text{H}_2\text{O}_2$  concentrations for 2 h (sample flow 2 L/min) using air sampler (Handy sampler, HS-7, Kimoto Electric Co., Ltd., Japan).

Atomic absorption spectrometer (AAS) used for analysis was manufactured by Shimadzu type AA-6601 equipped with lamps type HCl particular of analysis studied elements and corrected for background reference BGC-D2K with flame ( $\text{Air-C}_2\text{H}_2$ ) for determination of Cu and Pb and ( $\text{N}_2\text{O-C}_2\text{H}_2$ ) for determination of Al and with graphite furnace. The analytical used line of Al, Cu and Pb were at 309.27, 324.75

and 217.0 nm, respectively. A furnace ( $300 \pm 1$  °C) from Ecocell was used for drying samples.

**Samples preparation:** Samples were taken from different sections in a Aleppo company of cable industry, Syria: Al drawing, Cu drawing, Al stranding, Cu stranding, Packing and administration (located on the western side of the company's near factory of lead acid batteries and liquid gases) for determination Al, Cu, Cd and Pb pollutants.

Samples were collected using the TSP and PM<sub>10</sub>, dried at 105 °C, followed by crushing in a porcelain mortar, then dried again and mixed once again and kept in polyethylene packages for next procedures. A 0.5 g of the previous sample was treated with 20 mL solution content 5 M of HNO<sub>3</sub> and H<sub>2</sub>O<sub>2</sub> concentrations. The mixture was boiled on an electric heater for 0.5 h then filtrated and transferred into volumetric flask volume of 25 mL and the final volume was completed to 25 mL using distilled water.

**Total suspended particulates (TSP) monitoring:** The TSP were sampled in the different sections investigated on continuously all through the course of work and rest operations during the entire shift (a period of 8 h work). The particulate collecting used media was filters with a pore size of 0.3 µm.

**Inhaled particulates PM<sub>10</sub>:** The inhaled particulates were measured using PM<sub>10</sub> sampler. Inhaled dust is a new term used to describe dust that is hazardous when deposited anywhere in the respiratory track including the nose, mouth and lungs. Researchers generally recognize that these particulates < 10 µm and > 0.3 µm may cause significant adverse effects.

**Air-aluminum, copper and lead estimation:** The aluminum, copper and lead contents in the TSP and PM<sub>10</sub> samples were subjected to wet mixture digestion (20 mL solution content at 5 M of HNO<sub>3</sub> and H<sub>2</sub>O<sub>2</sub> concentrations) on a slow heating hot plate. The digested matter was filtered, made up to 25 mL using quartz double distilled water. The final analysis for aluminum, copper and lead estimation were performed by flame and graphite furnace AAS.

In this study concentrations of aluminum, copper and lead were measured in various sections of Aleppo company for cable industry, Syria. The aim of this study is to determine the amount of aluminum, copper and lead in the various sections which contribute of the most significant source of pollution using TSP, PM<sub>10</sub> and CT methods. Air lead can leak from the lead acid batteries and liquid gases plant adjacent to this factory from the western side.

## RESULTS AND DISCUSSION

**Environmental monitoring:** In the present study, personal monitoring of the TSP, PM<sub>10</sub> and CT were carried out in the working environment in different sections of the factory, when the wind direction from west to east. The TSP, PM<sub>10</sub> and air aluminum, copper and lead in working atmosphere noted in the different sections are presented in Tables 1-2.

TABLE-1  
RESPIRABLE PARTICULATE CONCENTRATIONS AND AIR ALUMINUM, COPPER  
AND LEAD LEVELS AT DIFFERENT SECTIONS USING TSP AND PM<sub>10</sub>  
(WIND DIRECTION FROM WEST TO EAST)

Section	TSP ( $\mu\text{g}/\text{m}^3$ ) mean*	PM <sub>10</sub> ( $\mu\text{g}/\text{m}^3$ ) mean*	Element	Air element in TSP ( $\mu\text{g}/\text{m}^3$ ) mean*	Air element in PM <sub>10</sub> ( $\mu\text{g}/\text{m}^3$ ) mean*	% Element in TSP mean*	% Element in PM <sub>10</sub> mean*
Al drawing	805.8	298.0	Al	84.0	7.00	10.420	2.36
			Cu	10.4	0.74	1.290	0.25
			Pb	28.3	12.90	3.510	4.33
Cu drawing	1128.3	290.3	Al	35.9	3.10	3.180	1.07
			Cu	221.0	16.80	19.600	5.79
			Pb	27.4	12.00	2.430	4.14
Al stranding	819.6	320.4	Al	58.1	5.00	7.090	1.55
			Cu	8.5	0.56	1.040	0.17
			Pb	24.8	11.10	3.020	3.46
Cu stranding	1103.4	312.1	Al	20.7	1.80	1.880	0.58
			Cu	78.2	5.80	7.090	1.87
			Pb	26.1	11.80	2.360	3.77
Packing	1003.9	350.2	Al	56.6	4.60	5.640	1.31
			Cu	5.4	0.36	0.540	0.12
			Pb	4.6	2.70	0.456	0.77
Administration	818.7	264.5	Al	2.7	0.23	0.326	0.087
			Cu	3.8	0.27	0.460	0.10
			Pb	77.5	32.60	9.470	12.33

\*Average of five measurements.

**Aluminum drawing:** The mean TSP and PM<sub>10</sub> were at 805.8 and 298.0  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead concentrations were at 84.0 and 7.0  $\mu\text{g}/\text{m}^3$ ; 10.4 and 0.74  $\mu\text{g}/\text{m}^3$ ; 28.3 and 12.9  $\mu\text{g}/\text{m}^3$  using TSP and PM<sub>10</sub>, respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 10.42 and 2.36 %; 1.29 and 0.25 %; 3.51 and 4.33 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 94.2, 11.2 and 72.3  $\mu\text{g}/\text{m}^3$ , respectively.

**Copper drawing:** The mean TSP and PM<sub>10</sub> were at 1128.3 and 290.3  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 35.9 and 3.10  $\mu\text{g}/\text{m}^3$ ; 221.0 and 16.8  $\mu\text{g}/\text{m}^3$ ; 27.4 and 12.0  $\mu\text{g}/\text{m}^3$  using TSP and PM<sub>10</sub>, respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 3.18 and 1.07 %; 19.6 and 5.79 %; 2.43 and 4.14 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 39.6, 238.5 and 71.9  $\mu\text{g}/\text{m}^3$ , respectively.

**Aluminum stranding:** In the aluminum stranding, the mean TSP and PM<sub>10</sub> were at 819.6 and 320.4  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 58.1 and 5.0  $\mu\text{g}/\text{m}^3$ ; 8.5 and 0.56  $\mu\text{g}/\text{m}^3$ ; 24.8 and 11.1  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 7.09 and 1.55 %; 1.04 and 0.17 %; 3.02 and 3.46 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 64.4, 9.1 and 68.3  $\mu\text{g}/\text{m}^3$ , respectively.

TABLE-2  
AIR ALUMINUM, COPPER AND LEAD LEVELS IN RESPIRABLE PARTICULATE  
AT DIFFERENT SECTIONS USING CHEMICAL TRAP (CT),  
(WIND DIRECTION FROM WEST TO EAST)

Section	Element	Total air element ( $\mu\text{g}/\text{m}^3$ ) mean*	% TSP element in total air element ( $\mu\text{g}/\text{m}^3$ ) mean*	% $\text{PM}_{10}$ element in total air element ( $\mu\text{g}/\text{m}^3$ ) mean*
Al drawing	Al	94.2	89.2	7.45
	Cu	11.2	92.9	6.61
	Pb	72.3	39.1	17.84
Cu drawing	Al	39.6	90.6	7.83
	Cu	238.5	92.7	7.05
	Pb	71.9	38.1	16.72
Al stranding	Al	64.4	90.2	7.70
	Cu	9.1	93.4	6.15
	Pb	68.3	36.3	16.19
Cu stranding	Al	23.1	89.6	7.79
	Cu	84.0	93.1	6.94
	Pb	71.2	36.6	16.50
Packing	Al	62.7	90.3	7.29
	Cu	5.8	93.1	6.21
	Pb	16.5	27.8	16.36
Administration	Al	3.0	88.4	7.62
	Cu	4.1	92.7	6.59
	Pb	152.0	51.0	21.46

\*Average of five measurements.

**Copper stranding:** In this section the mean TSP and  $\text{PM}_{10}$  were at 1103.4 and 312.1  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 20.7 and 1.8  $\mu\text{g}/\text{m}^3$ ; 78.2 and 5.8  $\mu\text{g}/\text{m}^3$ ; 26.1 and 11.8  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and  $\text{PM}_{10}$  were at 1.88 and 0.58 %; 7.09 and 1.87 %; 2.36 and 3.77 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 23.1, 84.0 and 71.2  $\mu\text{g}/\text{m}^3$ , respectively.

**Packing section:** In the packing section area the TSP and  $\text{PM}_{10}$  were at 1003.9 and 350.2  $\mu\text{g}/\text{m}^3$  respectively and air aluminum, copper and lead concentrations were at 56.6 and 4.57  $\mu\text{g}/\text{m}^3$ ; 5.4 and 0.36  $\mu\text{g}/\text{m}^3$ ; 4.6 and 2.7  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and  $\text{PM}_{10}$  were at 5.64 and 1.31 %; 0.54 and 0.12 %; 0.456 and 0.77 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 62.7, 5.8 and 16.5  $\mu\text{g}/\text{m}^3$ , respectively.

**Administration section:** In this section, which was considered as the control section, the mean TSP and  $\text{PM}_{10}$  were at 818.7 and 264.5  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead concentrations were at 2.7 and 0.23  $\mu\text{g}/\text{m}^3$ , 3.8 and 0.27  $\mu\text{g}/\text{m}^3$ ; 77.5 and 32.6  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and  $\text{PM}_{10}$  were at 0.326 and 0.087 %; 0.46 and 0.10 %; 9.47 and 12.23 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 3.02, 4.10 and 152.0  $\mu\text{g}/\text{m}^3$ , respectively.

This study showed that, very large lead levels despite the fact that this plant does not produce lead. This is due to the fact that, lead acid batteries and liquid gases plant adjacent to this factory from the western side, the wind direction often from west to east. The pollutants transported by the wind up; therefore waited for the opportunity east winds to determine the proportions of the contaminants in different parts of the plant (Tables 3-4).

TABLE-3  
RESPIRABLE PARTICULATE CONCENTRATIONS AND AIR ALUMINUM,  
COPPER AND LEAD LEVELS AT DIFFERENT SECTIONS USING TSP AND PM<sub>10</sub>  
(WIND DIRECTION FROM WEST TO EAST)

Section	TSP ( $\mu\text{g}/\text{m}^3$ ) mean*	PM <sub>10</sub> ( $\mu\text{g}/\text{m}^3$ ) mean*	Element	Air element in TSP ( $\mu\text{g}/\text{m}^3$ ) mean*	Air element in PM <sub>10</sub> ( $\mu\text{g}/\text{m}^3$ ) mean*	% Element in TSP mean*	% Element in PM <sub>10</sub> mean*
Al drawing	814.4	258.3	Al	85.20	6.55	10.460	2.540
			Cu	10.90	0.79	1.340	0.310
			Pb	0.39	0.18	0.048	0.070
Cu drawing	1130.2	256.0	Al	36.00	3.20	3.190	1.250
			Cu	228.70	16.8	20.240	6.580
			Pb	0.44	0.20	0.039	0.078
Al stranding	819.5	304.0	Al	58.10	5.35	7.090	1.760
			Cu	9.50	0.81	1.160	0.270
			Pb	0.40	0.22	0.050	0.072
Cu stranding	1100.1	314.6	Al	21.60	2.20	1.960	0.700
			Cu	78.20	6.26	7.090	1.990
			Pb	0.43	0.21	0.039	0.067
Packing	986.3	286.2	Al	55.20	4.29	5.600	1.500
			Cu	5.10	0.37	0.520	0.130
			Pb	0.21	0.17	0.021	0.059
Administration	995.2	294.5	Al	16.20	1.71	1.630	0.580
			Cu	7.30	0.68	0.730	0.230
			Pb	0.46	0.27	0.046	0.092

\*Average of five measurements.

**Aluminum drawing:** The mean TSP and PM<sub>10</sub> were at 814.4 and 258.3  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead concentrations were at 85.2 and 6.55  $\mu\text{g}/\text{m}^3$ ; 10.9 and 0.79  $\mu\text{g}/\text{m}^3$ ; 0.39 and 0.18  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 10.46 and 2.54 %; 1.34 and 0.31 %; 0.048 and 0.070 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 93.6, 11.6 and 0.42  $\mu\text{g}/\text{m}^3$ , respectively.

**Copper drawing:** The mean TSP and PM<sub>10</sub> were at 1130.2 and 256.0  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 36.0 and 3.20  $\mu\text{g}/\text{m}^3$ ; 228.7 and 16.8  $\mu\text{g}/\text{m}^3$ ; 0.44 and 0.20  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 3.19 and 1.25 %; 20.24 and 6.58 %; 0.039 and 0.078 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 39.3, 242.0 and 0.47  $\mu\text{g}/\text{m}^3$ , respectively.

TABLE-4  
AIR ALUMINUM, COPPER AND LEAD LEVELS IN RESPIRABLE PARTICULATE  
AT DIFFERENT SECTIONS USING CHEMICAL TRAP (CT)  
(WIND DIRECTION FROM WEST TO EAST)

Section	Element	Total air element ( $\mu\text{g}/\text{m}^3$ ) mean*	% TSP element in total air element ( $\mu\text{g}/\text{m}^3$ ) mean*	% PM <sub>10</sub> element in total air element ( $\mu\text{g}/\text{m}^3$ ) mean*
Al drawing	Al	93.60	91.0	7.00
	Cu	11.60	93.8	6.81
	Pb	0.42	92.9	42.86
Cu drawing	Al	39.30	91.7	8.14
	Cu	242.00	94.5	6.96
	Pb	0.47	93.6	42.55
Al stranding	Al	63.50	91.5	8.43
	Cu	10.10	94.1	8.02
	Pb	0.43	93.0	51.16
Cu stranding	Al	23.50	92.1	9.36
	Cu	82.50	94.8	7.59
	Pb	0.46	93.5	45.65
Packing	Al	60.70	90.9	7.07
	Cu	5.50	93.0	6.73
	Pb	0.28	75.0	60.71
Administration	Al	18.00	90.2	9.50
	Cu	7.80	93.3	8.72
	Pb	0.49	93.9	55.10

\*Average of five measurements.

**Aluminum stranding:** In the aluminum stranding, the mean TSP and PM<sub>10</sub> were at 819.5 and 304.0  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 58.1 and 5.35  $\mu\text{g}/\text{m}^3$ ; 9.51 and 0.81  $\mu\text{g}/\text{m}^3$ ; 0.40 and 0.22  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 7.09 and 1.76 %; 1.16 and 0.27 %; 0.050 and 0.072 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 63.5, 10.1 and 0.43  $\mu\text{g}/\text{m}^3$ , respectively.

**Copper stranding:** In this section the mean TSP and PM<sub>10</sub> were at 1100.1 and 314.6  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead levels were at 21.6 and 2.20  $\mu\text{g}/\text{m}^3$ ; 78.2 and 6.26  $\mu\text{g}/\text{m}^3$ ; 0.43 and 0.21  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 1.96 and 0.70 %; 7.09 and 1.99 %; 0.039 and 0.067 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 23.5, 82.5 and 0.46  $\mu\text{g}/\text{m}^3$ , respectively.

**Packing section:** In the packing section area the TSP and PM<sub>10</sub> were at 986.3 and 286.2  $\mu\text{g}/\text{m}^3$ , respectively and air aluminum, copper and lead concentrations were at 55.2 and 4.29  $\mu\text{g}/\text{m}^3$ ; 5.1 and 0.37  $\mu\text{g}/\text{m}^3$ ; 0.21 and 0.17  $\mu\text{g}/\text{m}^3$ , respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 5.60 and 1.50 %; 0.52 and 0.13 %; 0.021 and 0.059 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap were at 60.7, 5.5 and 0.28  $\mu\text{g}/\text{m}^3$ , respectively.

**Administration section:** In this section, which was considered as the control section, the mean TSP and PM<sub>10</sub> were at 995.2 and 294.5 µg/m<sup>3</sup>, respectively and air aluminum, copper and lead concentrations were at 16.2 and 1.71 µg/m<sup>3</sup>; 7.3 and 0.68 µg/m<sup>3</sup>; 0.46 and 0.27 µg/m<sup>3</sup>, respectively, (aluminum, copper and lead in TSP and PM<sub>10</sub> were at 1.63 and 0.58 %; 0.73 and 0.23 %; 0.046 and 0.092 %, respectively). The total mean air aluminum, copper and lead pollutants using chemical trap (CT) were at 18.0, 7.8 and 0.49 µg/m<sup>3</sup>, respectively.

### Conclusion

The results in this study showed that, the values of TSP, PM<sub>10</sub>, Cu and Al in working atmosphere much lower than the guideline values specified by the Occupational Safety and Health Administration (OSHA), while high levels of lead were more than the recommended maximum by OSHA, whereas, lead concentration in PM<sub>10</sub> very large, these inhaled particulates (< 10 µm) may cause significant adverse effects. This is due to the fact that lead acid batteries and liquid gases plant adjacent to this factory from the western side and the wind direction often from west to east.

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