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# Determination of Lead Pollutants in Acid Batteries and Liquid Gases in Aleppo-Syrian Company Using Total Suspended Particulate and Chemical Trap Methods

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Environmental and biological monitoring of lead in acid batteries and liquid gases in Aleppo-Syrian company using total suspended particulates of aerodynamics particle sizes larger 0.3 μm and chemical trap for total lead in air were studied. The lead contents in working atmosphere with total suspended particulates and chemical trap and in the blood of workers employed in different sections were measured by atomic absorption spectroscopy. The results showed that high mean of lead concentration in air in all different sections of the factory were more than the recommended maximum by National Ambient Air Quality Standards (NAAQS). The most polluted section is milling oxide with 2365 and 4787 μg/m$^3$, using total suspended particulates and chemical trap, respectively. The level of lead in blood was estimated to be at about 36 % in the employees of different sections (30-94 μg/dL) and it was higher than the values prescribed by American Conference of Governmental Industrial Hygienists (ACGIH).

**Key Words: Lead, Industrial particulates, Blood lead.**

## INTRODUCTION

An environmental and biological monitoring of a lead acid battery manufacturing unit was carried out to measure the respirable particulate matter, lead content in working atmosphere and blood lead levels of workers employed in different sections. The results showed that the high mean air lead concentration in buffing, plate cutting and pasting sections were at 1444.45, 430.14 and 277.48 μg/m$^3$, respectively. The mean blood lead levels of employees in these sections were also higher than the values prescribed by American Conference of Governmental Industrial Hygienists (ACGIH)[1].

Lead is toxic element and an environmental and occupational pollutant[2-5]. The primary routes of lead exposure are ingestion and inhalation[4] and adults are primarily exposed to it by their occupation through inhalation[5].

Lead, titanium and zinc in air particulate at Dhahran, Saudi Arabia, during and after Kuwait oil fires were determined[6]. In 1991, Gulf Crisis had the potential to enhance atmospheric metal concentrations and this study was designed to investigate this probability. Total suspended particulate (TSP) and inhalable particulate (PM10)

were collected and analyzed in order to determine lead, titanium and zinc using an inductively coupled argon plasma analyzer (ICAP). Significant ($p < 0.0l$) daily variations were found for lead, titanium and zinc concentrations (expressed as $ng/m^3$) in air particulate. Concentrations of lead in suspended TSP samples were higher than in the inhalable fraction (PM10). The maximum mean concentration of lead was found in TSP samples collected during June 1991, which gradually decreased through December 1991 and spiked again during June 1992. A yearly mean of 282 ± 144 ng of lead in one $m^3$ of air was calculated from the data of inhalation particulate collected in Dhahran. Lead poisoning is a chronic problem and automobile emissions may constitute a significant source of lead in air particulate in the Gulf region.

TSP, PM10 and PM2.5 were collected in three retirement facilities in the urban area of Vienna[7]. In addition, particulate matter and soil, vegetation and isopods were collected in the adjacent garden areas. The sampled materials were wet ashed and total lead and cadmium contents were determined. Lead and cadmium were analyzed by graphite furnace AAS. Particulate matter was dominated by PM2.5, in respect to both mass concentrations and to heavy metal contents. The indoor aerosol was found to be influenced by human activity, indoor sources and outdoor particles.

Some metallic elements in ambient air particulates were determined in Taichung Airport (Taiwan), Hong Kong, Los Angeles, southeast China, Athens (Greece) and Oxford[8-14].

This work is focused on the environmental and biological monitoring of lead in a lead acid battery and liquid gases in Aleppo-Syria company using total suspended particulates (TSP) of aerodynamics particle sizes larger 0.3 μm and chemical trap (CT). Lead content in working atmosphere with TSP and CT and blood lead levels of workers employed in different sections were measured by atomic absorption spectroscopy.

## EXPERIMENTAL

A study comprising environmental and biological monitoring was undertaken in the lead acid battery and liquid gases company situated near Aleppo city, north Syria, to ascertain the concentration of lead pollutants in various sections using TSP and CT. The enterprise had *ca.* 254 workers. The different investigated sections were the oxide mill, assembly and cleaning, smelting furnace, grid casting, pasting, maintenance-service and administration sections.

A high flow air sampler TSP ( HVAS, Instrument NO. AS-16, USA ) was used to collect samples for 8 working hours in every section of plant using a glass filter Whatman EPM 2000 High-Volume 1882-866. Another samples were collected in chemical trap (CT) (Fig. 1), by bubbling working atmosphere in solution content 5 M of $HNO_3$ and $H_2O_2$ 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 (Air-$C_2H_2$). The analytical used line of Pb were at 217.0 nm. A furnace (300 ± 1 ºC) from Ecocell was used for drying samples.

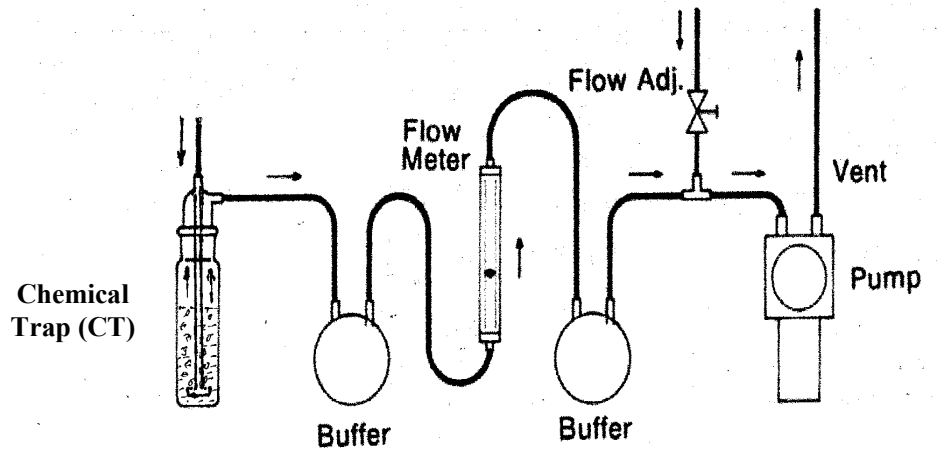


Fig. 1. Air sampler for chemical trap (CT)

**Samples preparation:** Samples were collected using the TSP, dried at 105 ºC, 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 $HNO_3$ and $H_2O_2$ 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.

**Environmental study**

**Total suspended particulates (TSP) monitoring:** Total suspended particulates 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 Whatman glass filters (EPM 2000 High-Volume 1882-866 ) with a pore size of 0.3 µ.

**Air-lead estimation:** The lead content in the TSP samples was subjected to wet mixture digestion (20 mL solution content at 5 M of $HNO_3$ and $H_2O_2$ 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 lead estimation was performed by flame AAS.

In this study concentration of lead were measured in various sections of lead acid battery and liquid gases in Aleppo-Syria company. The aim of this study is to determine the amount of lead in the various sections which contribute of the most significant source of pollution using both TSP and CT methods. The results showed that the air in department of the Oxide Mill has highest concentration of lead. The

amounts were at 2365 and 4787 μg/m$^3$ using TSP and chemical trap, respectively. The measurements of pollutions with lead in administration area were less and observed at 21.3 and 28.1 μg/m$^3$ using TSP and chemical trap, respectively. The second pollution section was assembly and cleaning unit where lead concentration was at 1012 and 2052 μg/m$^3$ using TSP and chemical trap, respectively. Lead content in working atmosphere with TSP and CT and blood lead levels of workers employed in different sections were measured by atomic absorption spectroscopy. The results showed that, high mean air lead concentration in all sections of the factory, more than the recommended maximum by National Ambient Air Quality Standards (NAAQS).

The smelting furnaces had high chimneys rise up 6 to 10 meters and during working hours, the furnace chimney emitting black or white smoke sometimes without pass to any pretreatment plant, leading to lead vapours emission and can be distributed far away depending on wind direction. Wind speed plays a role significant in the transfer of lead vapour to the long distances and different directions and sites.

The measurement of lead pollution concentration increase with the direction of the wind from west to east more than the other directions, but still less than the area of the oxide mill and the assembly and cleaning hall. Because the samples were taken at a height about 1.5 meters taking into concentration that the bulk of the lead fumes occur at the highest and above 1.5 meters. It should be mentioned here that, the lead contents in oxide mill and assembly and cleaning units were done indoor and the operated system can capture more fine particles leading to high lead concentration. Finally it should be pointed, that the amount of lead using a TSP was less than chemical trap, due to particulate filter used in TSP is more than 0.3 micrometers only, but the chemical trap is collecting all the particles from the different diameters, fumes of lead and all lead compounds.

**Biological monitoring:** Blood samples were taken from the workers through the analysis by medical specialists in Central Laboratory in Aleppo, Syrian Clinical Laboratory Association. The amount of lead in the blood content was estimated by the flame atomic absorption spectroscopy.

## RESULTS AND DISCUSSION

**Environmental monitoring:** In the present study, personal monitoring of the TSP and CT were carried out in the working environment in different sections of the factory. The TSP and air lead in working atmosphere noted in the different sections are presented in Tables 1 and 2.

**Oxide mill sections:** The mean TSP and air lead concentration were at 2945 and 2365 μg/m$^3$, respectively, (lead in total particulate was at 80.3 %). The amount of TSP and air lead in the oxide mill was high when compared to other sections of the factory. The total mean air lead pollutants using chemical trap (CT) was at 4787 μg/m$^3$.

TABLE-1
RESPIRABLE PARTICULATE CONCENTRATION AND AIR LEAD LEVELS AT DIFFERENT SECTIONS USING TSP

| Section | TSP (μg/m³) Mean* | Air lead (μg/m³) Mean* | % Lead in TSP Mean* |
|---|---|---|---|
| Oxide Mill | 2945 | 2365 | 80.3 |
| Assembly and cleaning | 2867 | 1012 | 35.3 |
| Smelting furnace | 2419 | 753 | 31.1 |
| Pasting | 1298 | 511 | 42.1 |
| Grid casting | 1021 | 357 | 35.0 |
| Administration | 260 | 21.3 | 8.2 |

*Average of five determinations.

TABLE-2
RESPIRABLE PARTICULATE CONCENTRATION AND AIR LEAD LEVELS AT DIFFERENT SECTIONS USING CHEMICAL TRAP (CT)

| Section | Total air lead (μg/m³) Mean* | % TSP lead in total air lead Mean* |
|---|---|---|
| Oxide Mill | 4787 | 49.4 |
| Assembly & cleaning | 2052 | 49.3 |
| Smelting furnace | 2210 | 34.1 |
| Pasting | 618 | 82.7 |
| Grid casting | 793 | 45.0 |
| Administration | 28.1 | 75.8 |

*Average of five determinations.

**Assembly and cleaning section:** In the assembly and cleaning (cleaning by compressed air) area, the mean TSP and air lead level were at 2867 and 1012 μg/m³ respectively, (lead in total particulate was at 35.3 %). The total mean air lead pollutants using chemical trap (CT) was at 2052 μg/m³.

**Smelting furnace section:** In the smelting furnace, the mean TSP and air lead level were at 2419 and 753 μg/m³, respectively, (lead in total particulate was at 31.1 %). The total mean air lead pollutants using chemical trap (CT) was at 2210 μg/m³.

**Pasting section:** In this section the mean TSP and air lead level were at 1298 and 511 μg/m³, respectively, (lead in total particulate was 42.1 %). The total mean air lead pollutants using chemical trap (CT) was at 618 μg/m³.

**Grid casting section:** In the grid casting area a low level of average TSP and air lead concentration were at 1021 and 357 μg/m³, respectively, (lead in total particulate was at 35.0 %); which indicates that the nature of the particulates were not rich in lead. The total mean air lead pollutants using chemical trap (CT) was at 793 μg/m³.

**Administration section:** In this section, which was considered as the control section, the mean TSP and air lead concentration were at 260 and 21.3 μg/m³, respectively, (lead in total particulate was at 8.2 %). The total mean air lead pollutants using chemical trap (CT) was at 28.1 μg/m³.

**Biological monitoring**

**Blood lead estimation:** The direct measurement of the lead level in the whole blood is widely used and reliable method of detecting and diagnosing lead poisoning. The American Conference of Governmental Industrial Hygienists (ACGIH) has listed the biological exposure index for blood lead as 30 µg/dL[5]. The mean blood lead levels of employees according to the different sections are arranged in decreasing levels and presented in Table-3.

TABLE-3
MEAN BLOOD LEAD LEVELS (µg/dL) OF EMPLOYEES ACCORDING TO DIFFERENT SECTIONS AND NUMBER OF EMPLOYEES SHOWING ABOVE 30 µg/dL OF LEAD-BLOOD ACCORDING TO SECTION

| Section | Number of employees | Amount of lead in the blood µg/dL Mean (Range) | Amount of lead in the blood No > 30 µg/dL | Percentage (%) |
|---|---|---|---|---|
| Smelting furnace | 11 | 39.3 (28.5-51.4) | 10 | 90.9 |
| Grid casting | 29 | 50.1 (39.8-61.9) | 9 | 31.0 |
| Pasting | 13 | 45.1 (29.7-51.3) | 12 | 92.3 |
| Oxide mill | 8 | 44.9 (39.2-47.7) | 5 | 62.5 |
| Assembly and cleaning | 35 | 38.6 (22.8-94.0) | 19 | 54.3 |
| Charging | 13 | 37.9 (22.4-41.8) | 7 | 53.8 |
| Maintenance-service | 75 | 28.2 (22.1-52.9) | 12 | 16.0 |
| Administration | 35 | 24.9 (20.5-34.8) | 5 | 14.3 |

Table-3 shows that, the percentage of employees' mean blood lead level > 30 µg/dL was as the follwing: 92.3, 90.9, 62.5, 54.3, 53.8, 31.0, 16.0 and 14.3 % in pasting, smelting furnace, oxide mill, assembly and cleaning, charging, grid casting, maintenance-service and administration, respectively. The study conducted by Krishnamurthy *et al.*[15] in 1988 at a similar factory showed that the blood lead levels in the workers engaged in the oxide mill, assembly, casting and formation sections were 56.56, 60.95, 59.28, 64.89 µg/dL, respectively. In the study[1] the blood lead levels in the plate buffing, plate cutting, assembly, pasting, grid casting, oxide mill, formation, maintenance and administration sections were 38.0, 34.9, 32.9, 29.8, 28.17, 29.73, 27.10, 25.31 and 17.77 µg/dL, respectively. Among the plate buffing workers, 88.23 % of employees had blood lead levels of more than 30 µg/dL. In the cutting and assembly sections 57.14 and 53.57 % workers, respectively, showed values higher than the prescribed blood lead levels. In the oxide mill and formation sections this percentage was at 33.33 %.

A study conducted by Cardozo dos Santos *et al.*[16] among 166 battery manufacturing workers showed 40 % of them had blood lead levels above 40 µg/dL. Another study conducted among 70 workers in the same occupation showed more than half of the workers had blood lead levels over 35 µg/dL and 10 % had levels above 60 µg/dL[17].

In conclusion, present study has revealed that in some sections of the factory the atmosphere contained high lead content and some employees had elevated blood lead levels. In addition, education of workers to improve their hygiene behaviour may be needed because eating during working hours increases their blood lead levels[18]. Moreover inadequate hand and face washing and unrestricted smoking at the workplace may result in sub clinical lead poisoning[19].

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