Cairo Air Improvement Project

Air Quality Monitoring Component

Development of a Lead Emissions Inventory for the Greater Cairo Area

Chemonics International, Inc.
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Acronyms and Abbreviations

μg	Micrograms
AP-42	A collection of emission factor data published by the USEPA that provides typical emission factors for various pollutants from various source types. The AP-42 emission factors are frequently used to estimate annual emissions when actual emission data (e.g. source test results) are not available.
CAIP	Cairo Air Improvement Project
CAPMAS	Central Authority for Planning, Mobilization, and Statistics
Cu	Copper
EEAA	Egyptian environmental Affairs Agency
FIRE	Factor Information Retrieval System
GOE	Government of Egypt
GOFI	General Organization for Industrialization
hr	hour
kg	kilogram
l	liter
m, m^3	Meter, cubic meters
mg	milligram
OEP	Organization for Energy Planning
Pb	Lead
Sec.	Secondary
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency

Executive Summary

As part of the Cairo Air Improvement Project (CAIP), a lead emission inventory is being developed for the greater Cairo area. The inventory is required to develop regulatory and control strategies, assess emission trends, and conduct modeling exercises. This report describes the initial effort in development of the inventory, provides preliminary lead emission estimates for various processes, and discusses the future refinement of the inventory.

Based on preliminary data, it is estimated that the total annual lead emissions in the Greater Cairo area are 722 metric tons. The annual emissions from secondary lead smelters are estimated to be 492 tons, which is approximately 68 percent of total estimated lead emissions. Cement production is estimated to be the second largest source of lead emissions (192 tons/year). However, no emission testing has been performed to verify the emission factor used for cement production emission estimates. Emission estimates are also provided for production of storage batteries, lead oxide, lead pipe, and copper alloys, as well as for using mazot fuel.

Future work for the Air Monitoring Component of CAIP will involve making improvements to the completeness and accuracy of the emission inventory. A source-testing program will be conducted to develop more accurate emission factors. Facility-to-facility survey techniques will be used to collect more accurate and comprehensive process and production data. A database is being developed to handle the emission inventory data. Periodic updates of the emission inventory, probably at annual intervals, will be performed.

Introduction

Studies that investigate the environmental health risks to Cairo residents invariably conclude that lead (Pb) is one of the area's major hazards. Lead is a toxic material that can affect the blood, nervous system, brain, and kidneys. Manifestations of lead exposure are anemia, encephalopathy, and kidney damage. The principal routes of human exposure are ingestion and inhalation.

Several references report ambient air lead levels up to 10 μg/m^3 in many areas of Cairo and lead levels in the range of 10–50 μg/m^3 in industrial areas.[1] Studies of blood lead levels in Cairo residents report that children, who are the most sensitive receptors in the population, have blood lead concentrations up to three times the WHO "safe" level.[2]

An important step in reducing health risks due to lead exposure was taken when a lead additive was removed from gasoline sold in the Greater Cairo Area. It is estimated that removal of the alkyl lead additive from gasoline probably reduced by more than one-half the quantity of lead emitted into Cairo's air. The action also reduced the general public exposure to lead from vehicular sources. However, high airborne lead levels still persist in areas where lead-emitting industries are located, and the exposure to residents of these areas remains a significant threat to human health. USAID, in cooperation with the Egyptian Environmental Affairs Agency (EEAA), have developed plans for abatement of lead from these sources.[3]

The Cairo Air Improvement Project (CAIP), which is funded by USAID and is being conducted under the auspices of the EEAA and the Organization for Energy Planning (OEP), is implementing plans for abatement of emissions from lead processing facilities. This effort involves assisting a major lead producer in the design and construction of a secondary lead smelter with state-of-the-art emission controls. Process modification and emission control design assistance is also being provided to smaller lead processing facilities to aid them in meeting the emission limitations specified in the Environmental Law, Law 4/1994.

Currently, there is no inventory of lead emissions in the Greater Cairo area on which to base regulatory strategies, conduct modeling exercises, nor assess emission trends after implementation of CAIP and other abatement measures. The initial effort being conducted by CAIP to develop a lead emission inventory for the greater Cairo area is discussed in this report.

Emission Inventory Data Collection Procedures

The development of an emission inventory for lead (or any other pollutant) in Egypt is confounded by the lack of data resources to identify relevant facilities and obtain accurate, current process and production data. Some information on identification and characteristics of licensed facilities was obtained from the General Organization for Industrialization (GOFI), the Central Authority for Planning, Mobilization, and Statistics (CAPMAS), and the Environmental Map of Egypt prepared by the EEAA.[4] However,

[1] References 1, 2, and 3.
[2] References 3 and 4.
[3] References 5 and 6.
[4] Reference 7.

we found that the most productive approach to data collection was facility-to-facility surveys. In addition, we discovered many unlicensed facilities existed that could only be identified by this approach. While the facility-to-facility surveys are time consuming, they are an indispensable means of obtaining accurate, current, and comprehensive source characteristics data. The secondary lead smelting, storage battery, lead pipe, and copper alloy production data given in this report were obtained by the facility surveys. Cement production usage data for the Greater Cairo Area was obtained from the National Cement Company and the Ministry of Industry. Mazot usage data for the Greater Cairo Area came from the Ministry of Petroleum.

A limited number of source tests were performed to obtain emission factor data for secondary lead smelters and for copper alloy foundries. The emission factor data calculated from these tests are presented in Table 1. A significant feature of the secondary lead smelter test results is the large difference in the emission data. Tests 1 and 2 were performed at facilities owned by the same individual. Test 3 was performed at a facility operated by another owner. The lead emission factors obtained from the three tests vary from 4.4 to 26.5 kg/ton of lead produced. AP-42 data was used to estimate fugitive lead emissions from the secondary lead smelters.[5]

Source testing was performed at one copper alloy foundry, which was producing brass castings that contained approximately 2 percent lead. The lead emission factor calculated from the tests was 0.03 kg/ton of product.

Three different fuels used in Egypt were analyzed for lead. The results of the fuel analyses are provided in Table 2. No residual lead was detected in gasoline or in solar

Table 1
Emission Factors Obtained from Source Tests

Test No.	Process	Furnace Description		Pb Emission Rate kg/hr[a]	Emission Factor kg/ton
		Type	Capacity		
1	Sec. Lead Smelter[b]	Rotary	4 tons	6.6	8.3
2	Sec. Lead Smelter[c]	Rotary	4 tons	3.5	4.4
3	Sec. Lead Smelter[c]	Rotary	4 tons	30	26.5
4	Brass/Bronze Foundry[c]	Crucible	150 kg	0.03	0.3

[a] Determined by averaging the results of at least two source tests.

[b] Smelter equipped with a low efficiency particulate control device. Particulate removal efficiency was not determined.

[c] Uncontrolled emissions data.

[5] Reference 8.

Table 2
Lead Analysis of Fuels

Sample Type	Lead Concentration
Gasoline	<0.125 mg/l
Solar-A	<0.125 mg/l
Solar-B	<0.125 mg/l
Solar-C	<0.125 mg/l
Mazot	3.9 mg/kg

(diesel) fuel, which is used both for vehicles and as a process heating fuel. Lead at a concentration of 4 grams/ton was detected in mazot, a widely used process heating fuel. The lead analysis data was used to calculate lead emissions from mazot used in the Greater Cairo area.

FIRE or USEPA AP-42 emission factors were used to estimate lead emissions from storage battery, lead oxide, lead pipe, and cement production.

Emission Inventory Results

The estimated annual lead emissions in the Greater Cairo area are summarized in Table 3. The estimated total airborne lead emissions for the area are 722 ton. Annual emissions from the 11 secondary lead smelters in the greater Cairo area are estimated to be 492 ton or approximately 68 percent of the total lead emissions in the area. The lead smelter emissions data are divided into two categories: A and B. Category A includes emissions data for three facilities operated by the same owner. We believe data for these lead smelters are the most accurate, since emission tests were performed at two of the three facilities. The higher of emission factors calculated from the two tests was used to provide a conservative emissions estimate for this category. Source tests were performed at only one of the eight Category B facilities. The test provided a significantly higher emission factor (see Table 1). The emission factor used to estimate annual emissions for the Category B lead smelters was calculated by averaging the data from the three emission tests (two Category A and one Category B facilities). Due to the large difference in the emission factors obtained from the source test results, there is probably greater uncertainty in the Category B emissions estimate.

The estimated annual lead emissions from cement production in Greater Cairo are 192 tons, or approximately 27 percent of the total of the total lead emissions. The

estimate of lead emissions from cement production was made using an emission factor selected from the FIRE database. The emission factor is for uncontrolled emissions and is applicable to production of cement by the dry process. Since lead emission testing of

Table 3
Preliminary Estimate of Airborne Lead Emissions in the Greater Cairo Area

Process	Number of Facilities	Annual Production[a]	Emission Factor	Est. Annual Emissions, Tons/year	Percent Total Air Emissions	Production Reference	Emission Factor Reference
A. Sec. Lead Smelting - Stack	3	32,400 tons	8.3 kg/ton	269	37	CAIP Survey	Source Tests[b]
A. Sec. Lead Smelting - Fugitive			5% of stack emissions	13	1.8	CAIP Survey	AP-42
B. Sec. Lead Smelting - Stack	8	15,360 tons	13 kg/ton	200	28	CAIP Survey	Source Tests[c]
B. Sec. Lead Smelting - Fugitive			5% of stack emissions	10	1.4	CAIP Survey	AP-42
C. Storage Battery Production	3	507,600 batteries	7.5 kg/1000 batteries	4	0.6	CAIP Survey	AP-42
D. Lead Oxide Production	2	2293 tons	7 kg/ton	16	2.2	Estimated[d]	AP-42
E. Lead Pipe Production	5	3624 tons	0.02 kg/ton	<0.1	<0.01	CAIP Survey	Assumption[e]
F. Cu Alloy Casting	211	13,313 tons	0.3 kg/ton	4	0.6	CAIP Survey	Source Test
G. Cement Production	3	9,575,879 tons	0.02 kg/ton	192	26.5	National Cement Co.	FIRE[f]
H. Fuel Combustion - Mazot	Unknown	3,422,000 tons	0.004 kg/ton	14	1.9	Petroleum Ministry	Fuel Analysis
Totals				722	100		

[a] Tons - metric tons (1000kg)

[b] Emission factor calculated from Test 1 source test data shown in Table 1. Tests 1 and 2 were performed at two on the three facilities included in the Category A secondary lead smelters. The upper limit value (Test 1) was used for the annual emissions calculation.

[c] Emission factor for Category B secondary lead smelters was calculated from average of all secondary lead smelter source test data shown in Table 1.

[d] Estimated from storage battery production data and assumption the one-half of lead in the batteries (total 9.1 kg) is lead oxide. Production of lead oxide for applications other than storage batteries is not considered in this calculation.

[e] Assumed same AP-42 emission factor as used for secondary smelting kettle furnace.

[f] FIRE emission factor for uncontrolled, dry-process cement production.

cement plants has not been performed, the accuracy the annual emissions estimate is unknown.

In general, the estimated annual lead emission data for other types of facilities in the Greater Cairo area was determined using USEPA AP-42 emission factors and production data obtained from the CAIP survey. Lead oxide production data was estimated by calculation of the quantity required to produce the annual number of storage batteries shown in Table 3. It is know that the facility that produces lead oxide for the battery production is located in the Greater Cairo area, but production figures are not currently available. The combined annual lead emissions from these other manufacturing processes are 38 tons, or approximately 5 percent of the total lead emissions for Greater Cairo.

Future Work

We believe that the initial effort on the emission inventory program has developed a reasonably comprehensive database of major lead-emitting facilities in the Greater Cairo area. However, additions to this list will be made as other facilities are identified. A survey will be performed to identify other industrial lead-emitting facilities that conduct operations such as soldering, lead pigment production, lead-covered cable production, and metal-type production. It is likely that emissions from these facilities will be a small fraction of the total annual lead emissions.

A source-testing program will be conducted to obtain more accurate emission factors. This effort will be concentrated on emission testing at the facilities that appear responsible for the highest lead emissions, namely, secondary lead smelters and cement plants.

Conclusions

The work described in this report represents initial efforts to develop a lead emission inventory for Greater Cairo. Prior to this study, there has been no effort to quantify the lead emissions within this geographical area. The study has developed the most comprehensive database of lead-emission sources, related process data, and production data available at this time. A preliminary identification of the primary source of lead emissions in Greater Cairo has been completed, and an initial estimate of annual lead emissions from these sources has been made. The results of this work will be used to focus the future effort to improve the accuracy of the emission estimates.

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A consortium assembled and managed by Chemonics International is performing the Cairo Air Improvement Project. Mr. Stasys Rastonis, Chemonics International, is the Chief of Party for the project.

Dr. Ibrahiem Abdel Gelil and Dr. Mohamed El-Zarka are responsible for administration of the CAIP within the EEAA and Dr. Ahmed Badreldin is responsible for administration of the CAIP within OEP. Ms. Elzadia Washington is the USAID technical representative for the project.

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Disclaimer

The opinions and conclusions stated in this report are those of the authors and do not necessarily represent those of USAID, EEAA, OEP, or any of the consulting organizations involved in the conduct of the program.

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