SOURCES OF ARSENIC, MONITORING THE WORKPLACE AND PROBLEMS INVOLVED

Mr. William L. Wagner
National Institute for Occupational Safety and Health

An overview of arsenic exposure in the United States copper smelting industry is presented, including measurements of airborne concentrations, respirability, and urinary excretion levels. Areas of high exposure are identified, and exposure of copper smelter workers is compared to exposure of users and manufacturers of pesticides. Problems encountered in collecting arsenic data and evaluting human exposure are also discussed.

The topic of the usual sources of arsenic exposure has been adequately covered by Mr. Nelson. However, you should be aware of recent NIOSH recommendations to the Department of Labor which make the copy of the inorganic arsenic criteria document given to you obsolete. It is being substantially revised. The airborne concentration currently recommended by NIOSH is "no detectable amount" using a certain method. The method given would detect 2 μg/cu m in a 15-minute sample. Also, in view of the current OSHA proposal for a standard of 4 μg/cu m as an 8-hour time weighted average, there will be a lot of other industries and operations where industrial hygienists are going to have to look for arsenic exposures. For instance, there is arsenic which is released into the environment when coal is burned. Another example is a material of special interest in this energy conscious time, oil shale. Some Colorado Plateau oil shales contain about .005 percent arsenic. This is much more arsenic than is found in many copper ores and even in some copper concentrates. The shale oil itself may be contaminated with as much as 50 ppm arsenic, and in the manufacture of synthetic crude oil, this arsenic must be removed. Obviously, a tremendous amount of arsenic will have to be handled in that industrial process.

I have been advised that waste material handled in the building of roads contains as much as 0.1 percent arsenic, a relatively considerable amount. To give you an idea of typical airborne environmental concentrations of arsenic, EPA data, collected in the mid 1950's, and data, collected by some states in the early 1960's, indicate that in smaller towns in the United States where there is an insignificant arsenic source, typical airborne levels are equal to or less than about 0.02 μg/cu m. In larger cities, arsenic levels are usually equal to or less than around 0.1 μg/cu m, with occasional excursions of higher levels. In smelter towns values will occasionally exceed 2 µg/cu m.

Figure 1 shows a comparison of some typical environmental airborne background concentrations of arsenic. The bars on the left represent the air levels of arsenic found in some towns in Montana. This data was collected during 1961 and 1962 and you can see that the levels are all below 0.1 µg/cu m with the exception of Anaconda, where a rather large smelter is located. The levels on the right side are for the cities of Portland, Cincinnati, Chicago, New York, and Los Angeles.

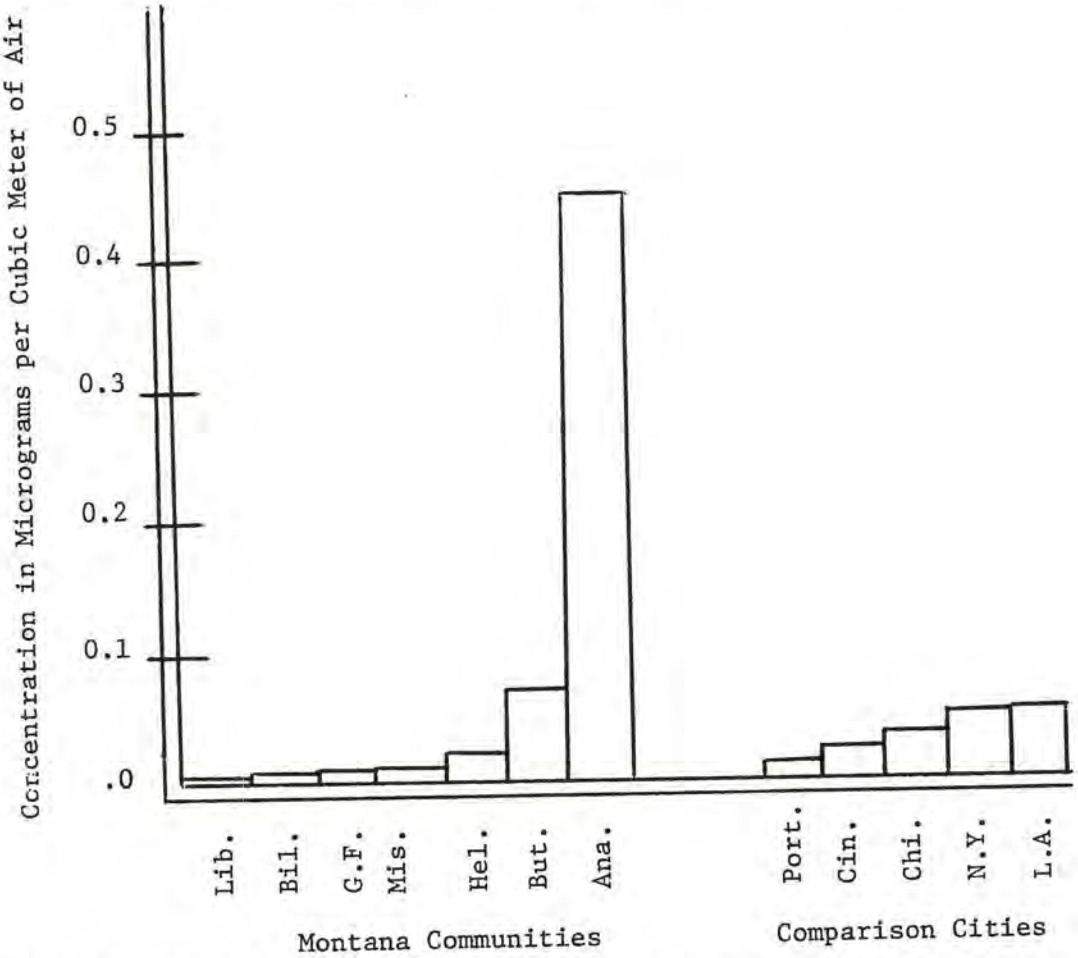

Figure 1 Average Arsenic in Air Content for Seven Montana Communities, June 1961 - July 1962

One of the major industries where there is exposure to inorganic arsenic is the smelting of copper. Data from some of the copper smelter survey reports from NIOSH's Salt Lake City facility give you an idea of the range of airborne levels of arsenic in that industry. Based on the Salt Lake City data, it appears that copper smelters fall into three groups with differing ranges of airborne arsenic concentrations based on the percent of arsenic in their concentrate. There are 15 copper smelters in the United States and we have some information on 14 of them. None of these smelters would fall into the lowest category having concentrates that contain about 0.001 to 0.01 percent arsenic. The airborne levels found usually were from equal to or less than 0.001 mg/cu m up to about 0.01 mg/cu m. These figures compare with the current OSHA proposal for an inorganic arsenic standard.

An intermediate group would include 3 smelters with the concentrate usually containing from about a 0.1 to 0.4 percent arsenic and airborne levels averaging about 0.05 mg/cu m. Keep in mind that these are ballpark values, because there are excursions and exceptions in every smelter.

The high group includes 2 smelters where the arsenic content in the feed is from about 1 to 7 percent. We have found airborne values in these smelters from essentially undetectable up to above 10 mg/cu m.

Table I shows data taken from a smelter where the concentrate was 0.003 percent and is a good example of some of the airborne values found in one of the cleaner smelters. Notice that almost all values are equal or less than 1 µg/cu m.

Table I, AIRBORNE ARSENIC - SMELTER PROCESSING CONCENTRATE WITH 0.003 PERCENT As

Location	Arsenic mg/cu m
#3 Side #2 Reverb., Chargers Floor, Converter End	<.001
#3 Side #2 Reverb., Chargers Floor, Converter End	.001
#6 Side #3 Reverb., Chargers Floor, Skimming End	<.001
#6 Side #3 Reverb., Chargers Floor, Skimming End	<.001
#6 Side #3 Reverb., Chargers Floor, Skimming End	<.001
#6 Side #3 Reverb., Chargers Floor, Skimming End	.001

Data in Table II is from a smelter where the concentrate content is about 0.01 percent arsenic. On the day these measurements were made the feed was 0.0008 percent. All the values are quite low, except the boiler repairman's personal sample, which was 0.5683 mg/cu m, was a value exceeding the current TLV.

Table II, AIRBORNE ARSENIC - SMELTER PROCESSING CONCENTRATE WITH 0.01 PERCENT As

TYPE	LOCATION	As mg/cu m
Personal	Tappers' Helper, South Side, Reverb. #1	<0.0002
Personal	Boiler Repair	0.5683
Personal	Spoutman	0.0043
Personal	Crane	<0.0002
Personal	Laborer, Anode Casting Area	<0.0003
Personal	Reverb. #2, North Side, Center, Charge Floor	<0.0002
Personal	Crane #1, South	<0.0002
Personal	Crane #2, Middle	<0.0010
Personal	Concentrate Feed Deck Between Crane #1 & #2	0.0077
Personal	Reverb. #1, South Side, Charge Floor	<0.0001
Personal	Reverb. #2, South Side, Center, Charge Floor	0.0298
Personal	Reverb. #1, North Side, Center, Charge Floor	0.0004

Two ways for exposure with arsenic in a copper smelter to occur are: (1) exposure to fume and dust (the fugitive emissions) from the heating and concentrate handling processes, and (2) exposure to flue dust by workers who routinely handle this material and by those who come into incidental contact with the dust while performing maintenance tasks. A boiler repairman was in an area where there was a lot of flue dust and consequently the filter he was wearing accumulated a lot of arsenic.

Data in Table III shows a smelter processing a concentrate containing about 0.2 to 0.4 percent arsenic. Notice that the airborne levels are higher than those in the preceeding Table II. Higher figures have been reported from this smelter.

Table III AIRBORNE ARSENIC - SMELTER PROCESSING CONCENTRATE WITH 0.2 - 0.4 PERCENT As

LOCATION	As mg/cu m
Converter Skimmer on #3	0.03
Converter Skimmer on #3	<0.01
Converter Skimmer on #3	<0.01
Center of Charge Floor, West Side	0.15
Center of Charge Floor, East Side	0.02
North East Side of Charge Floor	0.01
Center of Charge Floor, West Side	0.05
Slag Skimming Area, No. Side of #4 Reverb.	0.02
Matte Tapping Area, #4 Reverb., 15' Away	0.01

Data in Table IV is from a smelter where a concentrate containing about 1 percent is processed. Only data from the converter side is shown. Information from the reverb side showing levels as high as 8.2 mg/cu m are available.

TABLE IV, AIRBORNE ARSENIC - SMELTER PROCESSING CONCENTRATE WITH 1 PERCENT As

LOCATION	As mg/cu m
Crane Cab - No. 2	0.02
Puncher Aisle (Behind No. 2 Converter)	0.05
Skimmer Shack No. 5	0.06
Skimmer Shack No. 3	0.13
Skimmer Shack No. 1	0.10

Table V presents a composite of a number of samples taken in some 14 copper smelters in the United States and gives a pretty good idea of the exposures of the working population as a whole. It also identifies the higher risk workers. Notice that the reverbatory charge floor workers work in the highest airborne concentrations. We see this pattern repeated in smelter after smelter, so we are confident that these workers have the higher risk. There are, however, certain other maintenance workers and flue dust handlers who can also get some high exposures. These values represent 8-hour time weighted average exposures if one does not consider the use of respirators. Also, this arsenic is about 75 percent respirable.

TABLE V, AIRBORNE ARSENIC - INDUSTRY-WIDE AVERAGES

LOCATION	As mg/cu m
Reverberatory Furnace Charging Deck	0.04
Reverberatory Furnace Operators Deck	0.02
Converter Aisle	0.01
Anode Casting	<0.01

Our definition of respirable material is that which passes through miniature cyclone. This fact has been verified by other investigators who have found that the airborne arsenic in copper smelters is from 68 to 80 percent respirable.

Table VI contains an average of 156 samples taken again from 14 copper smelters in the United States. The average, 23, is quite low; the highest value reported, 170, is also reasonably low. We do have some other data, where in the smelters with higher airborne levels, the values are up to around 225 ug/liter in the urine. Again, nothing really excessive.

Table VI ARSENIC CONCENTRATION IN URINE

Element	Concentration in ug/liter Average	Highest Value	No. Samples
As	23	170	156

In sampling the environment for arsenic and in attempting to determine human exposure, we experience all the problems with airborne sampling for lead discussed yesterday. There is an additional problem too. Usually when surveying a smelter or any other type of industry, the investigator is looking for many things besides arsenic. With a given filter, one can get information on lead, zinc, cadmium, nickel, molybdenum, copper, and many other metals. If one wants data on arsenic, then all this other information is lost because of the requirements of the analytical procedure. So, in the past, the tendency has been to look for the other materials because the levels for arsenic were always low in relation to the TLV.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

HEALTH EFFECTS OF *OCCUPATIONAL LEAD and ARSENIC EXPOSURE*

A SYMPOSIUM

HEALTH EFFECTS
OF
OCCUPATIONAL LEAD AND ARSENIC EXPOSURE

A SYMPOSIUM

Edited By

Bertram W. Carnow, M.D.
University of Illinois School of Public Health
Contract Number 210-75-0026

Chicago, Illinois
February 24-25, 1975

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
Division of Surveillance, Hazard Evaluations and Field Studies

February 1976

For sale by the Superintendent of Documents, U.S. Government
Printing Office, Washington, D.C. 20402

SPONSORED BY: Society for Occupational and Environmental Health
National Institute for Occupational Safety and Health
United Church Board of Homeland Ministries
University of Illinois School of Public Health
Chicago Lung Association

SUPPORTED BY: National Institute for Occupational Safety and Health
United Church Board of Homeland Ministries

PLANNING COMMITTEE:

Bertram W. Carnow, Chairman
Edward J. Calabrese
Richard A. Lemen
Vaun A. Newill
John Zalusky

HEW PUBLICATION NO. (NIOSH) 76-134

The Editor or his staff prepared abstracts of the presentation when they did not accompany the author's manuscript.