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Arsenic Exposure Levels During Cleanup of Fly Ash and Dermatitis in an Air Sampling Technician

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Arsenic is an occupational, environmental and public health hazard (Adams, 1993; Yaqer et al., 1997; Ilgren, 2002). This metal can cause a number of diseases including cancer (Adams, 1983). It has been reported to cause occupational dermatitis in workers handling this substance (Adams, 1983; Mohamed, 1998); however, few literature reports exist on occupational exposure and non-malignant skin problems. The dermatitis has been identified as irritation with lesions consisting of perifollicular erthyma associated with burning and itching (Adams, 1983). Mostly this dermatitis occurs where dust collects under clothing or respirators and can be mixed with perspiration. Normally arsenic dermatitis is associated with areas where the greatest exposure concentration occurs (Adams, 1983)

Little data has been reported in the open literature on arsenic exposure from fly ash cleanup (Yager et al., 1997). This investigation provides data on exposure levels to arsenic during cleanup of fly ash at a power plant (maintenance outage) (Yager et al., 1997) and dermatitis reported in an air-sampling technician that collected samples.

MATERIALS AND METHODS

Personal air samples were collected from workers cleaning a large bin that stored fly ash from a coal-generating power station. During this activity, workers employed power-air purifying respirators and other personal protective equipment. All samples were collected from the breathing zone of workers. This power-generating station was located in the northeastern region of the United States and cleanup was performed in 2003. Sample pumps were operated at a flow rate of 1 to 2 lpm. Exposure results are reported as summary statistics. These results were categorized as task-length average (TLA) and time-weighted average (TWA) (Lange, 2002). TLA sampling time ranged from 240 to 600 minutes. TWA was calculated as an 8-hour workday. All samples were analyzed according to the National Institute of Occupational Safety and Health (NIOSH) 7300 ICP method (NIOSH, 1997). No value was at or below the reported limit of detection. This work was approximately two weeks in length.

Personal performing this cleanup used respirators and other personal protective equipment. The technician did not routinely stay in the work area except for brief observations and to collect the samples. Distribution was determined using the Shapiro-Wilk test and outliers by the Grubbs test (non-transformed data). Confidence coefficient (probability) of at least 5% of workers exceeding the respiratory protection factor (PF) established by Occupational Safety and Health Administration (OSHA) for airborne arsenic was determined using a graphic method (Leidel et al. 1977). Calculations were performed using summary TLA and TWA values.

RESULTS AND DISCUSSION

As previously reported (Lange, 2002) for other airborne contaminates, TLA and TWA airborne arsenic levels are non-normally distributed at a 5% level. This non-normality is supported by the extreme geometric standard deviation (GSD). None of the values for TLA or TWA were outliers.

Summary statistics for air samples are shown in the table 1. These data show that there was a wide range of exposure levels. On average, worker exposure (arithmetic mean – AM) exceeded the OSHA permissible exposure limit (PEL) (10 ug/m^3) for airborne arsenic. The probability of exceedance of the PEL and the PF of a half-mask (PF is 10 or 100 ug/m^3) is 100%. The driving factor for this exceedance of probability is the extreme GSD and two samples being 469 and 512 ug/m^3. These data indicate that arsenic cleanup of fly ash requires employment of at least a full-face respirator (PF of 50 or 500 ug/m^3).

When examining exposure levels using geometric mean (GM), TLA or TWA, exposures are near or below the PEL. If the GMs were used in determining probability of overexposure for a half-mask respirator, this value would be greater than 75% for either TLA or TWA, primarily due to the GSDs.

Variability of exposure in these workers poses the question as how to determine what values to use in evaluating exposure. Historically, selection of personal protective equipment has been based on the AM. However, an appellant court ruled (United States Court of Appeals, 1991) that the GM is the value to be used in determining overexposure. Previous investigations (Armstrong, 1992) have suggested that the AM is the best measure for chronic toxicants. The extreme variability of these samples (TLA and TWA) is probably due to measurements involving different work activities as suggested by the range, GSD and standard deviation (SD). The high probability of exceeding the PF of a half-mask respirator using the GM supports using a full-face respirator. So regardless of which summary measurement employed (AM, GM) the minimal respiratory protection is suggested to be a full-face respirator.

The technician collecting samples for this project developed dermatitis with skin irritation associated with burning and itching. He spent little time

Table 1. Summary statistics for personal air samples, in ug/m^3, during cleaning a storage facility containing coal generated fly ash.

Sample Categorization	Nos. of Samples	AM	GM	SD	GSD	Range
TLA	8	141.7	13.2	218.8	24.2	0.09-512
TWA	8	88.5	3.3	136.8	6.5	0.05-320

in the work area, with time spent involved with observation and air sample collection. A previous study (Yager et al., 1997) reported that technicians experience low exposure levels to airborne arsenic during outages. However, he did handle cassettes for preparation and shipment to the laboratory, which did not involve use of gloves. It is suggested that the dermatitis were due to arsenic exposure of the skin, although other causes are certainly possible (e.g. fungal infection). Since this dermatitis developed while performing work at the site and signs/symptoms consisted of erthyma (irritation), burning and itching, its cause is most likely due to arsenic (Adams, 1983). Use of non-steroid creams and cessation of exposure resulted in reduced dermatitis suggesting arsenic as the cause. Previous reports have indicated similar findings in workers that had exposure to arsenic (Adams, 1983; Mohamed, 1998). Since this person was not exposed above the PEL, it demonstrates that some may have sensitivity to this metal resulting in an occupational dermatitis at low levels and short duration's (i.e. handling cassettes).

REFERENCES

Armstrong BG (1992). Confidence interval for arithmetic means of lognormal distribution exposures. American Ind Hyg Assoc 53: 481-485.

Adams RM (1983). Occupational skin disease, Grune & Stratton, Inc., New York, pgs 205-206.

Ilgren EB (2002). Health risks from exposures to asbestos and inorganic metals due to collapse of the world trade center: an environmental residential survey. Indoor Built Environ 10: 361-383.

Lange JH (2002). Impact of asbestos concentrations in floor tile on exposure during removal. Int J Environ Hlth Res 12: 293-300.

Leidel NA, Busch KA, Lynch JR (1977). Occupational Exposure Sampling Strategy Manual. DEHW (NIOSH) Publication Number 77-173, National Technical Information Service Number PB-274-792. National Institute for Occupational Safety and Health, Cincinnati, Ohio.

Mohamed KB. (1998). Occupational contact dermatitis from a tin-smelting factory. Contact Dermat 38: 224-225.

National Institute for Occupational Safety and Health (1997). Manual of analytical methods, National Institute for Occupational Safety and Health, Cincinnati, Ohio.

United States Court of Appeals (1991). American iron and steel Institute and Bethlehem Steel Corporation vs. Occupational Safety and Health Administration. Fed Reporter Second Series (DC Cir.), 939, 975-1010.

Yager JW, Hicks JB, Fabianova E. (1997). Airborne arsenic and urinary metabolites during boiler cleaning operations in a Slovak coal-fired power plant. Environ Hlth Persp 105: 836-843.