

ACUTE TOXICITY OF FLY ASH COLLECTED FROM A MUNICIPAL INCINERATOR BURNING TRASH

Y. ALARIE • M. Iwasaki • M. Stock • R.C. Pearson • D.J. Lisk

Graduate School of Public Health, University of Pittsburgh Pittsburgh, PA, and Toxic Chemicals Laboratory, Cornell University, Ithaca, NY, USA

INTRODUCTION

There are about 70 operating municipal refuse incinerators in the United States and about 250 more are planned. The ash produced typically contains high concentrations of heavy metals¹ and a wide range of toxic organics including polychlorinated dibenzodioxins and dibenzofurans.² Therefore, there is a concern about possible health effects of the ash among those residing downwind from such incinerators as well as on workers within the plants. We have undertaken some preliminary studies with exposures of guinea pigs to very high concentrations of fly ash collected from one municipal refuse incinerator.

Experimental

Twenty kilograms of fly ash was collected from a municipal incinerator. After drying and mixing the ash was analyzed for cadmium, lead and zinc by wet ashing with nitric and perchloric acids followed by anodic stripping voltametry.³ Mercury was determined by flameless atomic absorption analysis.⁴

The ash was placed into a Pitt No. 3 aerosol generator⁵ for resuspension in air of fine particles which were delivered to an exposure system for guinea pigs.^{6,7} This system consisted of a central glass chamber to which four glass chambers were attached, each holding one guinea pig. Each of these animal chambers functioned as a flow-through whole body plethysmograph.⁸ Therefore they permitted indirect measurement of tidal volume (VT), from the pressure changes (ΔP) created by each breath as monitored by a sensitive pressure transducer attached to each chamber.⁸ Four male Hartley guinea pigs (300-350g) were obtained from Hazleton Research Products, Inc. and were exposed to the ash 6 hours/day for 5 consecutive days. The exposure concentration was 314 mg/m³ and the particle size was 3.2 μ m mass aerodynamic diameter. Prior to and immediately following each exposure each animal was challenged with 10% CO₂ in 20% O₂ and 70% N₂. ΔP and respiratory frequency (f) were measured during air breathing and CO₂ challenge.^{8,9} Similar CO₂ challenges were also conducted on days 6-9, 14, 16, 21, 26-30, 35 and 50 following exposure. Euthanasia was performed on day 50 using pentobarbital. Kidneys, livers and lungs were removed. Lungs were fixed using intratracheal infusion of 10% buffered formaldehyde held at 25 cm H₂O for two hours prior to continued fixing in the same solution. Before and after fixation lung weights were taken and lung volumes were measured by water displacement. Four guinea

pigs were used as controls and treated as the exposed animals except that no dust was delivered to the exposure system.

RESULTS

Table I lists the heavy metals and carbon content of the ash and Table II lists the heavy metals found in tissues of guinea pigs 45 days after termination of exposure. Significant elevation was found in the lungs of the exposed animals as compared to the controls.

Following the first exposure and during the five exposure days there was no change from preexposure for VT measured during air breathing. However f was lower. During CO₂ challenge both VT and f were lower. This effect persisted for all exposure days. Measurements made after the 5 exposure days and until sacrifice at day 50 indicated recovery towards control values. However, there was histopathological findings in all animals ranging from moderate to severe pneumoconiosis. This consisted of interstitial macrophage reaction with a number of dense, black granule-laden macrophages. Airways were moderately constricted and a moderate degree of smooth muscle hypertrophy of the airways and vessels was present. Thickening of alveolar septa by macrophages and foci of granule-laden macrophages was observed. There was no increase in lung weights in comparison to the controls. Lung volumes after fixation were reduced by 50% in two animals, probably because of the constricted airways preventing the entry of fixative as in controls.

DISCUSSION

Fly ash from refuse incinerators will vary greatly because of the nature of the operation. Nevertheless, the results indicate that a very high concentration was needed to induce an abnormal ventilatory response to CO₂ on an acute basis. The reduction in VT during CO₂ was just below 50% of control. This level of effect can be induced by 13 mg/m³ of cotton dust,¹⁰ 1.5 mg/m³ of paraquat,¹¹ or 50 mg/m³ hexamethylene diisocyanate trimer.¹² Therefore the dust tested was not very potent in inducing an acute pulmonary effect. The delayed effects, as indicated from microscopic examination of the lungs were important and it would therefore be appropriate to investigate such dusts with repeated exposures at low concentrations to investigate the possible chronic effects. Airways constriction with smooth muscles hypertrophy suggest the possible development of chronic obstructive lung disease. This could be followed functionally by flow-volume measurements which can be made in guinea pigs.⁹

REFERENCES

1. Greenberg, R. R., Zoller, W. H. and Gordon, G. E.: Composition and Size Distributors of Particles Release in Refuse Incineration. *Environ. Sci. Technol.* 12:566-573 (1978).
2. Eiceman, G. A., Clement, R. E. and Karasek, F. W.: Analysis of Fly Ash From Municipal Incinerators for Trace Organic Compounds. *Anal. Chem.* 51:2343-2350 (1979).
3. Gajan, R. J. and Larry, D.: Determination of Lead in Fish by Atomic Absorption Spectrophotometry and Polarography, I. Development of the Methods. *J. Assoc. Off. Anal. Chem.* 55:727-732 (1972).
4. Hatch, W. R. and Ott, W. L.: Determination of Sub-microgram Quantities of Mercury by Atomic Absorption Spectrophotometry. *Anal. Chem.* 40:2085-2087 (1968).
5. Weyel, D. A., Ellakkani, M., Alarie, Y., and Karol, M.: An Aerosol Generator for the Resuspension of Cotton Dust. *Toxicol. Appl. Pharmacol.* 76:544-547 (1984).
6. Alarie, Y., Ferguson, J. S., Stock, M. F., Weyel, D. A., and Schaper, M.: Sensory and Pulmonary Irritation of Methyl Isocyanate in Mice and Pulmonary Irritation and Possible Cyanidelike Effects of Methyl Isocyanate in Guinea Pigs. *Environ. Health Perspect.* 72:159-167 (1987).
7. Ellakkani, M. A., Alarie, Y., Weyel, D., Mazumdar, S. and Karol, M. H.: Pulmonary Reactions to Inhaled Cotton Dust: An Animal Model for Byssinosis. *Toxicol. Appl. Pharmacol.* 74:267-284 (1984).
8. Wong, K. L., Alarie, Y.: A Method for Repeated Evaluation of Pulmonary Performance in Unanesthetized, Unrestrained Guinea Pigs and its Application to Detect Effects of Sulfuric Acid Mist Inhalation. *Toxicol. Appl. Pharmacol.* 63:72-90 (1982).
9. Alarie, Y and Schaper, M.: Pulmonary Performance in Laboratory Animals Exposed to Toxic Agents and Correlations with Lung Diseases in Humans. *Lung Biology in Health and Disease. Pathophysiology and Treatment of Inhalation Injuries*, pp 67-122. J. Loke, Ed. Dekker, N.Y. (1988).
10. Ellakkani, M. A., Alarie, Y., Weyel, D. A. and Karol, M. H.: Concentration-Dependent Respiratory Response of Guinea Pigs to a Single Exposure of Cotton Dust. *Toxicol. Appl. Pharmacol.* 80:357-366 (1985).
11. Burleigh-Flayer, H. and Alarie, Y.: Concentration-Dependent Respiratory Response of Guinea Pigs to Paraquat Aerosol. *Arch. Toxicol.* 59:391-396 (1987).
12. Ferguson, J. S., Schaper, M., Alarie, Y.: Pulmonary Effects of a Polyisocyanate Aerosol: Hexamethylene Diisocyanate Trimer (HD1t) or Desmodur N (DES-N). *Toxicol. Appl. Pharmacol.* 89:332-346 (1987).

Table I

Heavy Metals and Carbon Content of Collected Fly Ash for Exposure of Guinea Pigs. Concentration Given on the Basis of Dry Weight.

Item (units)	
Cadmium (ppm)	477
Lead (ppm)	2134
Mercury (ppm)	25
Zinc (ppm)	14301
Carbon (%)	7.34

Table II

Concentrations of Heavy Metals in Tissues of Guinea Pigs Exposed to Refuse Incinerator Fly Ash. Measurements Made 45 Days After 5 Daily Exposures of 6 Hours Each at an Exposure Concentration of 314 mg/m³

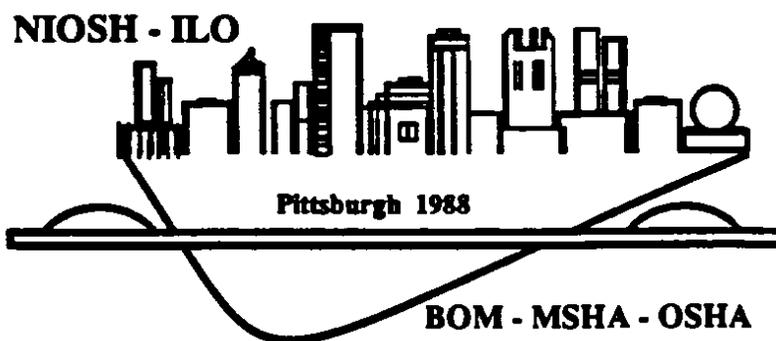
(Parts per million (dry weight of metal in tissue))

	Controls	Exposed
Cadmium in lung	0.20 ± 0.02	1.45 ± 0.17
Cadmium in kidney	1.16 ± 0.22	1.91 ± 0.23
Cadmium in liver	0.41 ± 0.07	0.97 ± 0.11
Lead in lung	1.25 ± 0.22	6.58 ± 0.46
Lead in kidney	0.40 ± 0.06	0.62 ± 0.14
Lead in liver	0.23 ± 0.03	0.34 ± 0.03
Zinc in lung	68.50 ± 7.06	110.48 ± 5.63
Zinc in kidney	89.45 ± 4.18	94.39 ± 7.31
Zinc in liver	93.63 ± 6.12	115.48 ± 12.74
Mercury in lung	0.16 ± 0.04	0.32 ± 0.03

^a
Means ± standard error.

Proceedings of the VIIth International Pneumoconioses Conference Part
Transactions de la VIIe Conférence Internationale sur les Pneumoconioses Tome
Transacciones de la VIIa Conferencia Internacional sobre las Neumoconiosis Parte

II



Pittsburgh, Pennsylvania, USA—August 23–26, 1988
Pittsburgh, Pennsylvanie, Etats-Unis—23–26 août 1988
Pittsburgh, Pennsylvania EE. UU—23–26 de agosto de 1988



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health



Sponsors

International Labour Office (ILO)
National Institute for Occupational Safety and Health (NIOSH)
Mine Safety and Health Administration (MSHA)
Occupational Safety and Health Administration (OSHA)
Bureau of Mines (BOM)

November 1990

DISCLAIMER

Sponsorship of this conference and these proceedings by the sponsoring organizations does not constitute endorsement of the views expressed or recommendation for the use of any commercial product, commodity, or service mentioned.

The opinions and conclusions expressed herein are those of the authors and not the sponsoring organizations.

DHHS (NIOSH) Publication No. 90-108 Part II