

# Occupational Lead Poisoning, Animal Deaths, and Environmental Contamination at a Scrap Smelter

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**Abstract:** Occupational lead poisoning and environmental contamination were evaluated at a lead scrap smelter. Thirty of 37 employees (81 per cent) had blood lead levels of  $\geq 80 \mu\text{g}/100\text{ml}$ , indicating unacceptable absorption, and 35 had free erythrocyte protoporphyrin (FEP) levels  $>60 \mu\text{g}/100\text{ml}$  rbc, indicating toxicity of lead on heme metabolism in red blood cells; eight current and previous employees had been hospitalized with lead colic, and another with encephalopa-

thy. Levels of lead in surface soil (1,800 ppm) and vegetation (20,000 ppm) at the smelter were high and decreased with distance. Animals on nearby pasture had died, and lead levels in the blood, milk, and hair of large and small animals were elevated. Adults living within 100 meters of the smelter had higher blood and hair lead levels than controls, who lived at greater distances, but there was no evidence in them of lead toxicity. (Am. J. Public Health 66:548-552, 1976)

## Introduction

Lead recovery plants or scrap smelters are located throughout the United States and each year reclaim approximately 500,000 metric tons of lead from batteries and other lead products.<sup>1</sup> While scrap smelters account for less than 1 per cent of total lead emissions in this country,<sup>2</sup> they have been reported to cause increased lead absorption and lead poisoning in humans and animals<sup>3</sup> as well as localized environmental contamination.<sup>4-6</sup>

This report describes a recent, severe episode of occupational poisoning and environmental contamination at a lead recovery plant in Alabama. Investigations were undertaken in 1972 following the discovery by the Alabama Department of Public Health that several employees of the smelter had been hospitalized for symptomatic lead poisoning.

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## Background

The smelter is located on the outskirts of Troy, population 11,482 (1970 U.S. Census), a city in southeastern Alabama. It opened in 1968 as a small concern, grew rapidly, and in 1972 reclaimed over 9,000 metric tons of lead, most of it from used automobile batteries. The plant was equipped in 1970 with a baghouse (chamber of fabric air filters), and with efficient operation of that system, annual stack lead emissions should have averaged 10-15 tons.<sup>7</sup> Actual emissions, however, may have been greater because of recurrent baghouse fires and the practice of occasional bypassing of the baghouse. Lead was probably also dispersed from uncovered waste heaps on the plant property. The terrain nearby the smelter is flat pastureland. Average annual rainfall is approximately 125cm; winds are generally light and from the southwest (data from U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, NC).

## Investigation

On October 6, 1972, following the discovery that men from the smelter had been hospitalized with lead poisoning, personnel from the Alabama Department of Public Health and from the Center for Disease Control obtained medical and occupational histories on 33 of the 37 then current laborers and on all four office workers. Each employee was asked his current job category, and company records were exam-

**TABLE 1—Blood Lead, Free Erythrocyte Protoporphyrin, and Hemoglobin Levels in Smelter Employees by Job Location at Smelter, Troy, Alabama, October 1972**

Job Location	Number of Employees	Blood Lead ( $\mu\text{g}/100\text{ml}$ )		FEP ( $\mu\text{g}/100\text{ml rbc}$ )		Hbg (gm)	
		Mean	Range	Mean	Range	Mean	Range
Sawmill	9	104	83–122	879	237–1780	13.0	11.5–14.8
Skip Hoist	6	97	84–127	666	52–1452	14.1	12.6–15.8
Furnace	8	97	66–124	854	370–1446	12.8	11.2–15.0
Alloying kettles	6	91	67–108	754	475–1150	12.9	11.1–14.7
Shop	4	83	80–85	379	161–596	14.7	13.0–16.0
Office	4	60	43–76	271	40–502	15.6	13.0–20.4

ined to determine length of employment at the smelter. Details of hospitalization were obtained by review of medical records at the one local hospital. A venous blood sample was obtained from each participating employee and analyzed for lead content by modified Delves' cup atomic absorption spectrophotometry,<sup>8</sup> for free erythrocyte protoporphyrin (FEP) level by the method of Granick et al.,<sup>9</sup> and for hemoglobin content. At the same time, interviews were conducted with eight members of two families who resided 50 and 100 meters, respectively, from the smelter. Family members were questioned about symptoms of lead poisoning, practice of pica, as well as about duration of residence near the smelter, occupation, use of pottery for culinary purposes, and "moonshine" whiskey consumption. Hair samples for lead analysis and venous blood samples for lead, FEP, and hemoglobin analyses were obtained from six members of these families. Blood and hair samples were also obtained from ten adult volunteers who had resided 1.6–11.3 kilometers from the smelter for the two preceding years. Hair was washed four times in detergent, rinsed four times in deionized water, dried for 12 hours at 60° C, and analyzed for lead by modified Delves' cup atomic absorption spectrophotometry.<sup>8</sup> Carbon rod measurements (Varian Techtron) were done for hair samples with low lead content.

Blood lead levels of  $\geq 40\mu\text{g}/100\text{ml}$ , the level denoting undue lead absorption,<sup>2</sup> were found in all employees tested at the smelter, including a secretary employed for only ten weeks (Table 1). Levels of  $\geq 80\mu\text{g}/100\text{ml}$ , which according to standards proposed by the National Institute for Occupational Safety and Health indicate unacceptable absorption that poses a risk of lead poisoning,<sup>3</sup> were found in 30 of the 33 laborers. FEP levels were elevated to  $> 60\mu\text{g}/100\text{ml}$  of packed red blood cells (rbc), the upper limit of normal<sup>9</sup> in the laboratories of the Center for Disease Control, in all but two of the employees tested. Persons employed for  $> 10$  weeks were significantly more likely to have high elevations in FEP than were persons employed for shorter periods (Table 2); this finding may be related to red blood cell turnover time.

All nine persons hospitalized with lead poisoning at the local hospital from June 1970 through September 1972 were smelter employees. Hospitalized patients were male laborers, 18 to 55 years of age, with admission blood lead levels (in a local laboratory) of 78–128 $\mu\text{g}/100\text{ml}$ . Eight had been

diagnosed as having lead colic, and one had confusion and hallucinations which abated without specific therapy after five weeks.

No blood lead levels  $\geq 40\mu\text{g}/100\text{ml}$  were found in members of the two families living adjacent to the smelter. However, adults in these families did have slightly higher mean blood lead levels (mean values, 25 $\mu\text{g}/100\text{ml}$  vs. 19 $\mu\text{g}/100\text{ml}$ ) and higher hair lead levels (mean values, 93 ppm vs. 6 ppm) than control adults residing elsewhere in Troy; none of the adults in the families adjacent to the smelter had been employed by the smelter, and no family members gave a history of pica, "moonshine" consumption, or of other potential exposure to lead. No FEP values  $> 60\mu\text{g}/100\text{ml rbc}$  were seen in the healthy adults living adjacent to the smelter.

#### Environmental Studies

Surface soil samples and samples of unwashed vegetation were collected for lead analysis along two transects drawn to the north and northwest from the smelter stack. In addition, surface soil samples and unwashed vegetation samples were obtained from geologically similar sites 6 and 16 kilometers away. Samples of washed garden vegetables and of house dust were collected at the two homes adjacent to the smelter. Water samples were taken from three springs, a pond, and a stream located within 800 meters of the smelter.

Dust and soil samples were dried for 12 hours at 105° C, pulverized mechanically, dissolved in 20 per cent nitric acid, and analyzed for lead content by modified Delves' cup atomic absorption spectrophotometry.<sup>8</sup> Water was also analyzed

**TABLE 2—Duration of Employment and Free Erythrocyte Protoporphyrin (FEP) Levels in Smelter Employees, Troy, Alabama, October 1972**

Weeks Employed	Distribution of FEP Levels ( $\mu\text{g}/100\text{ ml rbc}$ )	
	$< 500$	$\geq 500$
$\leq 10$	11	1
$> 10$	6	19
$\chi^2 = 12.34, p < 0.001$		

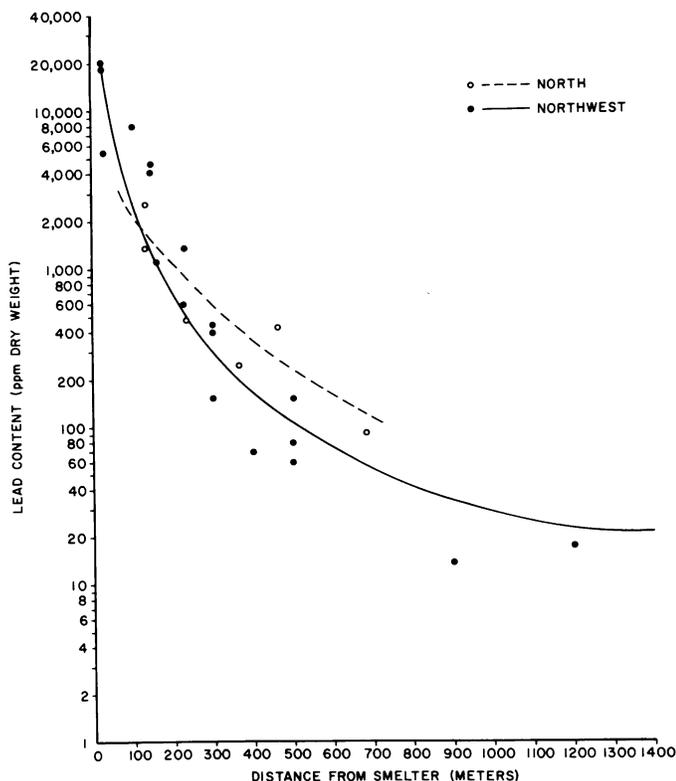
by atomic absorption spectrophotometry. Samples of vegetation\* were dried for 24 hours at 103° C, ashed in a muffle furnace, dissolved in 20 per cent nitric acid, and analyzed for lead content by atomic absorption spectrophotometry.

The lead content of surface soil (1,800 ppm maximum) and of unwashed plants (20,000 ppm maximum) was highest immediately adjacent to the smelter property (25 meters distant from the main stack) and decreased rapidly in the first 500 to 600 meters along each transect (Figures 1 & 2); however, lead levels above those found in control samples (approximately 10 ppm for both plants and soil) could be found as far distant as 1 kilometer. The lead levels in washed garden vegetables were all  $\leq$  2.4 ppm, except in one sample of collards (26 ppm).

The lead content in dust samples from the two homes adjacent to the smelter was very high (16,200 and 7,200 ppm, respectively); by contrast, the previously reported lead content of dust samples from suburban Philadelphia was 830 ppm.<sup>10</sup> All water samples tested contained  $<$  5 ppb of lead; the U.S. Environmental Protection Agency's recommended standard for lead in drinking water is  $\leq$  50 ppb.<sup>11</sup>

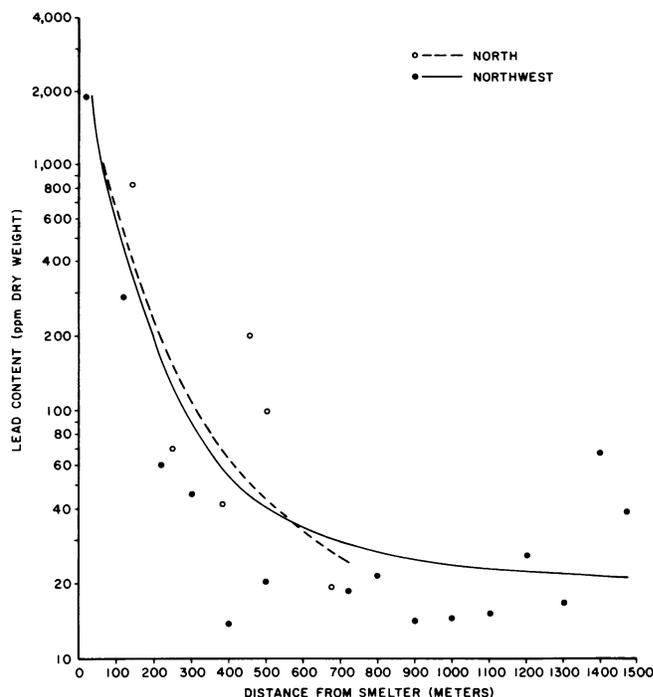
**Animal Studies**

Three farmers who grazed cattle and horses near the smelter were queried concerning illness or deaths in their



**FIGURE 1—Lead Content of Vegetation, by Distance and Direction from Smelter, Troy, Alabama, 1972**

\*Analyses performed by Chemical Services Branch, Region IV, Surveillance and Analysis Division, U.S. Environmental Protection Agency, Athens, GA.



**FIGURE 2—Surface Soil Lead Content, by Distance and Direction from Smelter, Troy, Alabama, 1972**

herds. One reported that in February 1972, 12 of his 20 cows had developed fever, diarrhea, ptalism, irritability, ataxia, and convulsions five weeks after having been grazed on fresh pasture within 300 meters of the smelter; seven of the 12 affected cows subsequently died, and another failed to gain weight. This farmer also reported that a Shetland pony had developed inspiratory dyspnea and anorexia in the summer of 1972 after having been allowed to graze in an orchard 400 meters from the smelter; symptoms disappeared when the pony was returned to the barn and fed commercial feed. The farmer had encountered no similar illness in 35 previous years of grazing his cattle and horses in those areas. The other farmers, who grazed their herds 700 and 900 meters from the smelter, respectively, and who fed their cattle hay supplements from more distant pastures reported no unusual problems in their herds. All three denied exposure of their animals to paint, storage batteries, oil, grease, or insecticides.

The families living adjacent to the smelter reported that since 1971 at least 21 dogs and cats had died after several days of vomiting, ataxia, irritability, apparent blindness, and convulsions. No illness had occurred in their pets before that time; the dogs had all been vaccinated against rabies.

Samples of blood, milk, and hair (full length) were obtained from cows on the three farms, and blood and hair samples were taken from horses, dogs, and cats. Control samples of blood and hair were obtained from a group of 17 horses of different breeds at the Center for Disease Control, Lawrenceville, Georgia, laboratories and from ten Shetlands at the Tuskegee Institute School of Veterinary Medicine, Tuskegee, Alabama. Control samples from cattle, dogs, and cats were obtained near Troy, but at locations beyond 6 ki-

**TABLE 3—Blood, Hair, and Milk Lead Levels and Free Erythrocyte Protoporphyrin Levels in Cattle, Troy, Alabama, 1972**

Distance from Smelter	Blood lead ( $\mu\text{g}/100\text{ ml}$ )			Hair Lead (ppm)			Milk Lead ( $\mu\text{g}/100\text{ ml}$ )			FEP ( $\mu\text{g}/100\text{ ml rbc}$ )		
	No.	Mean	(CI)*	No.	Mean	(CI)*	No.	Mean	(CI)*	No.	Mean	(CI)*
300 meters	20	102	(93–111)	20	98	(79–117)	4	42	NA	20	1009	(797–1221)
400 meters	4	52	NA†	4	3	NA	2	13	NA	4	403	NA
700 meters††	6	39	(34–44)	6	52	(39–65)	1	7	NA	6	125	(93–157)
900 meters††	9	27	(21–33)	9	4	(3–5)	4	8	NA	9	118	(91–145)
Controls	42	16	(15–17)	42	3	(2.7–3.3)	4	5	NA	41	93	(89–97)

\* 95% confidence interval

† Numbers too small to obtain confidence intervals.

†† These animals also received hay supplements from more distant pastures.

lometers from the smelter. Additional dog and cat samples were collected at Tuskegee. Blood, milk, and hair samples from all species were analyzed for lead content,<sup>8</sup> and the bovine blood samples for FEP as well.<sup>9</sup>

Levels of lead in blood, hair, and milk decreased with distance from the smelter (Tables 3 and 4). The difference in lead levels between cattle grazed closest to the smelter (300 meters) and controls was highly significant ( $p < 0.005$  by student's *t*-test). FEP levels in cattle were shown to increase logarithmically with arithmetic increases in the blood lead level.

## Discussion

The human, environmental, and animal data collected in this investigation implicate the lead scrap smelter in Troy, Alabama, as a major local source of lead contamination. The temporal distribution of the human cases and of the animal deaths suggests that the severity of the contamination must have increased sharply after 1970, coincidental with increases in smelter production.

It may be suspected that inhalation of airborne lead plus ingestion of lead from dust produced the increased lead uptake in workers,<sup>3</sup> and that the same sources contributed to the minimally increased intake observed in persons residing

nearby.<sup>12</sup> Lead absorption in animals would have resulted primarily from ingestion of contaminated forage, dust, and soil.<sup>4</sup>

Disruption of heme biosynthesis, colic, and encephalopathy were the health consequences noted here among the workmen with excessive exposure to lead. The additional possibility exists that these men may be at increased risk in future years of developing pulmonary or renal cancer,<sup>13</sup> hypertension, or chronic nephritis<sup>13–15</sup> as the result of their exposure to lead.

Many of the features of this episode have been recorded previously in the areas surrounding other primary<sup>12, 16–18</sup> and secondary<sup>4–6, 19, 20</sup> lead smelters. Occupational poisoning, contamination of air and soil, animal deaths, and absorption of lead by members of nearby communities, particularly children, appear to be rather common occurrences in such locales. A disturbing postscript to the present episode was the discovery that between July 1973 and January 1975, 21 additional workers from the Troy smelter were diagnosed as having had lead poisoning and six were hospitalized. It would appear that strict monitoring and regulation of occupational and environmental health in the lead smelting industry is necessary.

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**TABLE 4—Blood and Hair Lead Levels in Horses, Dogs, and Cats. Troy, Alabama, 1972**

Species	Distance from Smelter	Blood Lead ( $\mu\text{g}/100\text{ ml}$ )			Hair Lead (ppm)		
		No.	Mean	(CI)*	No.	Mean	(CI)*
Horses	400 meters	1	26	NA†	1	14	NA
	Controls	27	15	(14–16)	10	6	(3–9)
Dogs	50 meters	1	945	NA	1	472	NA
	700 meters	2	31	NA	1	32	NA
Cats	Controls	13	25	(18–32)	7	5	(2–8)
	100 meters	1	97	NA	1	55	NA
	400 meters	0	—	—	1	29	NA
	900 meters	4	58	NA	4	5	NA
	Controls	4	71	NA	3	6	NA

\*95% confidence interval

†Numbers too small to obtain confidence intervals.

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**Lead Poisoning in Industry Circa 1750**

“The potters who fashion earthen vessels with leaden glass are subject to the same kind of pain (The most severe cramps, not only of the stomach but in the intestines also). . . .

“A man of thirty years in the calcination of red lead inhaled Saturnine vapors, with a mild taste; the next day there was intolerable pain about the umbilicus with a persistent stricture of the intestine. Then followed nausea, vomiting, disturbing pains of the heart and cold sweating. The day after, the pain affected his left hand slightly with loss of motion. . . .

“Indeed such and so many poisons are hidden among metallic poisons, the diggers of red lead daily prove who are subject to dyspnoea, phthisis, cachexia, tremors of the limbs, painful colics, paralysis, and, although their lungs are mostly affected, the effluvia of red lead admitted into the vital parts, attacks the cerebrum and nerves, so that tremors, stupor and worse paralyzes arise. . . . No wonder that seven women who were married to men in the mines, all suffered a premature death from their poisonous breath. . . . Indeed the animals infected by this same poison commonly become bloated, soon lose their motion, and moreover die when unconscious. The diggers in mines are daily seen to suffer in climbing the rounds of the ladders from the pits where poison is concentrated falling backwards in the pits, because of inertia of the hands and flaccidity of the feet.

“Thus the potters applying burnt and calcined lead to glass vases while they grind the lead, smear the vases with liquid lead, before they are placed in the furnace, whose poison is dissolved or scattered in the water, they take up through their nostrils, their mouth and their whole body, tremors appear in the hands and soon they are paralysed.”

DeColica Pictonum  
Theodore Tronchin, Geneva, 1757