DIOXIN-CONTAINING ATTIC DUST AND HUMAN BLOOD SAMPLES COLLECTED NEAR A FORMER WOOD TREATMENT FACILITY

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Introduction

A wood treatment facility operating in southern Alabama, from at least the 1960's to the mid 1990's, released dioxins and other hazardous substances into the surrounding community. The facility used a variety of chemicals including pentachlorophenol (PCP), chromated copper arsenate (CCA), and creosote as insecticides to treat wood. Wood waste and ash from incineration activities on site containing PCP, dioxins, furans, creosote, chromium, and arsenic were dumped on the site and left exposed to the wind, creating an airborne contaminant plume. The former wood treatment facility is located immediately adjacent to two isolated cities with a combined population of 2,400 people.

The health hazards associated with the released contaminants are numerous and significant. Arsenic, chromium[VI], and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) are "known human carcinogens."[1] Creosote's main constituent, polycyclic aromatic hydrocarbons (PAHs), are "reasonably anticipated to be human carcinogens."[2] Non-cancer diseases related to these contaminants include (but are not limited to): diabetes,[3] thyroid disorders,[4] dyslipidemia,[4] coronary artery disease[4], peripheral neuropathy,[5] hypertension,[6] and bronchitis.[7] Because of the wide range of significant health risks associated with the compounds released from the facility, the task of characterizing the residents' historic exposure was addressed in this study.

Sampling attic dust is a useful means of evaluating exposure, since dust settling within attics is often preserved from weathering, providing a "time capsule" of contaminants associated with dust.[8,9] Over the years, dust from the outside environment finds its way into the attic and settles. The levels of contaminants within the attic dust provide a means to evaluate the resident's potential historical exposure to those contaminants via airborne dust.

Sampling human blood for dioxins is suggestive of past exposure to dioxins because of dioxins' relatively long half-life in blood. In one study, the half-life was estimated at 7.1 years (range of 2.9-26.9 years) for 2,3,7,8-TCDD in a group of 36 Vietnam veterans.[10] A subsequent study of 343 Vietnam veterans, which included the 36 veterans in the prior study, calculated a half-life estimate of 8.7 years (95% CI of 8.0–9.5 years).[11] The estimated half-lives for dioxin congeners other that 2,3,7,8-TCDD ranged from 3.5 to 15.7 years in a separate study.[12]

Methods

Blood samples were collected from 21 current and past residents of Florala and Lockhart, AL and analyzed to evaluate levels of dioxins and furans. The whole blood samples were collected in March 2006. After collection, samples were immediately shipped to Severn Trent Laboratories (STL) in Sacramento, CA. STL analyzed the blood lipid content gravimetrically and determined the levels of dioxins and furans in the blood serum in general accordance with US Environmental Protection Agency (EPA) Method 8290. Results were reported as picograms of dioxins/furans per gram of lipid in the blood.

Attic sampling was performed in March 2006, in 11 buildings located within a one-mile radius of the former wood treatment facility. Samples were collected using a High Volume Simplified Small Surface Sampler (HVS4) in general accordance with American Society for Testing and Materials (ASTM) method D5438, "Standard Practice for Collection of Floor Dust for Chemical Analysis." At least 52 grams of attic dust, the minimum amount required to perform dioxin/furan, PAH, chromium, copper, and arsenic analysis, were collected at each house. PAHs were evaluated in accordance with Method 8270C. Dioxins/furans were analyzed in accordance with EPA Method 8290. Metals were analyzed in accordance with Method 6020.

Toxic Equivalents (TEQs) were used to evaluate concentrations of dioxins and PAHs. The levels of dioxin TEQs in the attic and blood samples were quantified using dioxin and dioxin-like compound TEF values cited by the US EPA in 1989.[13] TEF values assigned to carcinogenic PAHs by the US EPA (1993) were used to calculate the total PAH TEQs.[14] The TEFs relate the toxicity of carcinogenic PAHs to benzo[a]pyrene.

Results

The results of the dioxin/furan analysis of blood samples are presented below in Table 1. The average total dioxin TEQ concentration in the residents' samples was 36.6 pg/g lipids (95% CI 24.3-49.0 pg/g lipid).

Table 1. Dioxin/furan total TEQ concentrations in human blood samples collected near a former wood treatment facility.

Resident Number	Total Dioxin TEQ Concentration (pg/g lipids)	Resident Number	Total Dioxin TEQ Concentration (pg/g lipids)	Resident Number	Total Dioxin TEQ Concentration (pg/g lipids)
1	111.06	8	48.87	15	50.33
2	16.29	9	25.22	16	57.00
3	26.39	10	65.03	17	7.40
4	15.58	11	37.07	18	35.00
5	10.71	12	69.98	19	2.10
6	10.22	13	54.98	20	2.70
7	25.26	14	43.84	21	54.00

The results of the attic sampling dust analysis are presented in Table 2. The PAH analyses were performed twice (Run 1 and Run 2) due to the high values detected in the samples by the laboratory. Both runs were performed using the same methods. The mean total dioxin TEQ concentration was 145 ng/kg. The average levels of arsenic, chromium and copper were 29.8, 21.7, and 33.9 mg/kg, respectively. The average amount total PAH TEQs detected in the attic samples was 0.98 mg/kg.

Table 2. Concentrations of contaminants in attic dust samples collected near a former wood treatment facility.

Sample Number	Total Dioxin TEQ (ng/kg)	Arsenic (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Total PAH TEQ (mg/kg)	
					Run 1	Run 2
1	**59.9**	**6.0**	**32.8**	22.8	**0.64**	**0.77**
2	**84.9**	**8.0**	**39.6**	33.2	**0.57**	**0.57**
3	**8.4**	**2.0**	18.5	8.6	**0.09**	0.05
4	**47.7**	**7.0**	15.6	28.8	**0.76**	**0.76**
5	**84.3**	**7.8**	16.6	26.5	**0.18**	**0.10**
6	**29.3**	**3.1**	11.9	26.4	**1.07**	**1.18**
7	**378.8**	**261.0**	25.2	44.7	**0.35**	**0.38**
8	**501.5**	**14.0**	27.7	122.0	**2.25**	**0.20**
9	**30.0**	**3.0**	17.8	13.3	0.04	0.01
10	**286.5**	**5.0**	17.4	18.3	**0.22**	**0.25**
11	**88.5**	**10.7**	15.7	28.4	**7.62**	**3.60**

Bold values: Concentrations that exceed the U.S. EPA Region 9 PRG value.

Discussion

The concentrations of dioxins measured in the blood samples from residents of Florala and Lockhart exceeded the 90th percentile total dioxin levels found in the general U.S. adult population based on the National Health and Nutrition Examination Survey (NHANES).[16] The Centers for Disease Control and Prevention (CDC) National Center for Health Statistics conducts a biomonitoring program through the NHANES. The NHANES study is a cross-sectional, representative survey designed to collect information about the health and diet of the civilian, non-institutionalized population of the U.S. Approximately 3,200 people were sampled for the NHANES for dioxins in blood in 1999-2000 and 2001-2002. The 90th percentile concentration of total dioxin TEQs in U.S. adults was 30 pg/g lipid using EPA TEF values.[14] The average concentration of total dioxin TEQs the sampled residents was 36 pg/g lipid, suggesting that these individuals experienced an average level of dioxin exposure that is greater than the level of exposure that 90% of the U.S. adult population experiences. It is also important to consider that 36 pg/g lipid is the present-day average concentration in the blood samples. Considering the half-life of dioxin and the long history of dioxin release, the historical concentrations of dioxin in the sampled residents' blood were likely more significant in the past.

Concentrations of dioxin, arsenic, and PAHs found in the attic samples exceeded the U.S. Region 9 soil combined exposure cancer risk Preliminary Remediation Goal (PRG) values (Table 3).[15] The U.S. EPA PRG values are guidelines for remediating contaminated sites and are developed to be health protective of health of the general population, including particularly sensitive sub-populations.[15] Alabama is located within EPA Region 4 which uses the PRG values adopted by EPA Region 9. The total dioxin TEQ concentrations in the attic dust exceed the PRG values by approximately 2 to 128 times. Arsenic concentrations exceed the PRG values by about 5 to 653 times. Nine of the eleven attic sample concentrations of PAH TEQs are above the PRG values, exceeding the values by approximately 2 to 123 times.

Table 3. U.S. EPA Region 9 PRG values for relevant compounds.[15]

Compound	PRG for Combined Soil Exposure Routes
Dioxin	3.9 ng/kg
Arsenic	0.39 mg/kg
Chromium	30 mg/kg
Copper	3,100 mg/kg
Benzo[a]pyrene (PAH)	0.062 mg/kg

Conclusions

The levels of dioxins, arsenic, and PAHs in the attic dust and blood samples indicate a very significant potential for related health effects in these communities. Because the attic dust samples showed elevated levels of dioxins, arsenic, and PAHs, there is evidence that residents were exposed to dust containing potentially unsafe levels of these contaminants. The present-day average total dioxin TEQ concentrations in the blood samples demonstrate that the residents were exposed to greater dioxin levels than approximately 90% of the general U.S. adult population. Historically, these concentrations were even more significant, considering dioxin's long half-life in blood. These results illustrate the elevated risk that the sampled residents experienced from exposure to hazardous contaminants released by the nearby former wood treatment facility.

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