DIOXIN LEVELS IN ASH AND SOIL GENERATED IN SOUTHERN CALIFORNIA FIRES

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ABSTRACT: We investigated the levels of polychlorinated dioxins (PCDDs) and polychlorinated furans (PCDFs) in ash and topsoil following the 2007 wildfires in southern California. Seventeen samples were collected from three different fires that burned in three counties. The production of PCDD/F exceeded the range of levels commonly reported in the literature and suggests that some of the high values could influence ambient levels. The highest detected values and levels of congeners were found in areas were homes where burned, followed by areas with agriculture and brush, respectively. Using WHO_{2005} TEFs, TEQ values ranged from 1.3 to 1,680 pg/g (ppt) (n=17; Median=3.29 ppt; Average=140.44 ppt). Of these, two samples taken at a burned home in a rural area surrounded by trees had the highest levels of TEQ at 1,680 ppt and 396 ppt, respectively. Tetrachlorodibenzo-*p*-dioxin (TCDD) was detected in eight of the 17 samples with a range between 0.691 to 72.8 ppt (n=8; Median=2.01 ppt; Average=16.62 ppt). Dioxin profiles show large variations in the amounts and composition. On a percentage basis, our data show characteristics similar to forest fires, which are dominated by OCDD (Average = 90%; highest value = 344,000 ppt) and 1,2,3,4,6,7,8-HpCDD (Average = 10%; highest value = 37,700 ppt). The high-end of the TEQ values for PCDD/Fs and TCDD indicate that higher values in the environment do not necessarily reflect industrial activity; moreover, reporting only average statistics without complete data sets may result in misleadingly interpretations of environmental concentrations. Our findings show that forest fires, especially in areas where homes are present apparently can lead to a range in concentrations with the highest levels well above median or mean values. In addition, in areas where forest fires are likely isolated high concentrations of dioxins or furans, including 2,3,7,8-TCDD, do not necessarily imply industrial activity.

INTRODUCTION

In October 2007, 14 fires, covering approximately 310-square miles from San Diego to Malibu, burned in southern California. The US Environmental Protection Agency (EPA) considers forest fires as a major contributor to dioxins (PCDDs) and furans (PCDFs) in the US; however, the literature suggests that the concentrations of these compounds in ash and soils following forest fires are relatively low. We examined the ash immediately following the 2007 southern California fires to test the hypothesis that fires are trace contributors.

SITE DESCRIPTION AND METHODLOGY

We collected a total of 17 samples from separate fires in Orange County, Riverside County, and San Diego County. The Orange-County fire started on October 21, 2007 and eventually burned 166 homes and 28,445 acres. The samples were taken from sites in an area with chaparral brush. The Riverside-County fire started on October 22, 2007 and burned 411 acres in an agricultural growing area. Samples were taken in an area where the dominant vegetation was avocado trees. The San Diego-County fire burned 9,472 acres and destroyed 206 homes, 2 businesses, and 40 outbuildings. Again, samples were taken in an area were the dominant vegetation was avocado trees. However, several homes in the area had also been burned and we sample within the footprint of the burned homes.

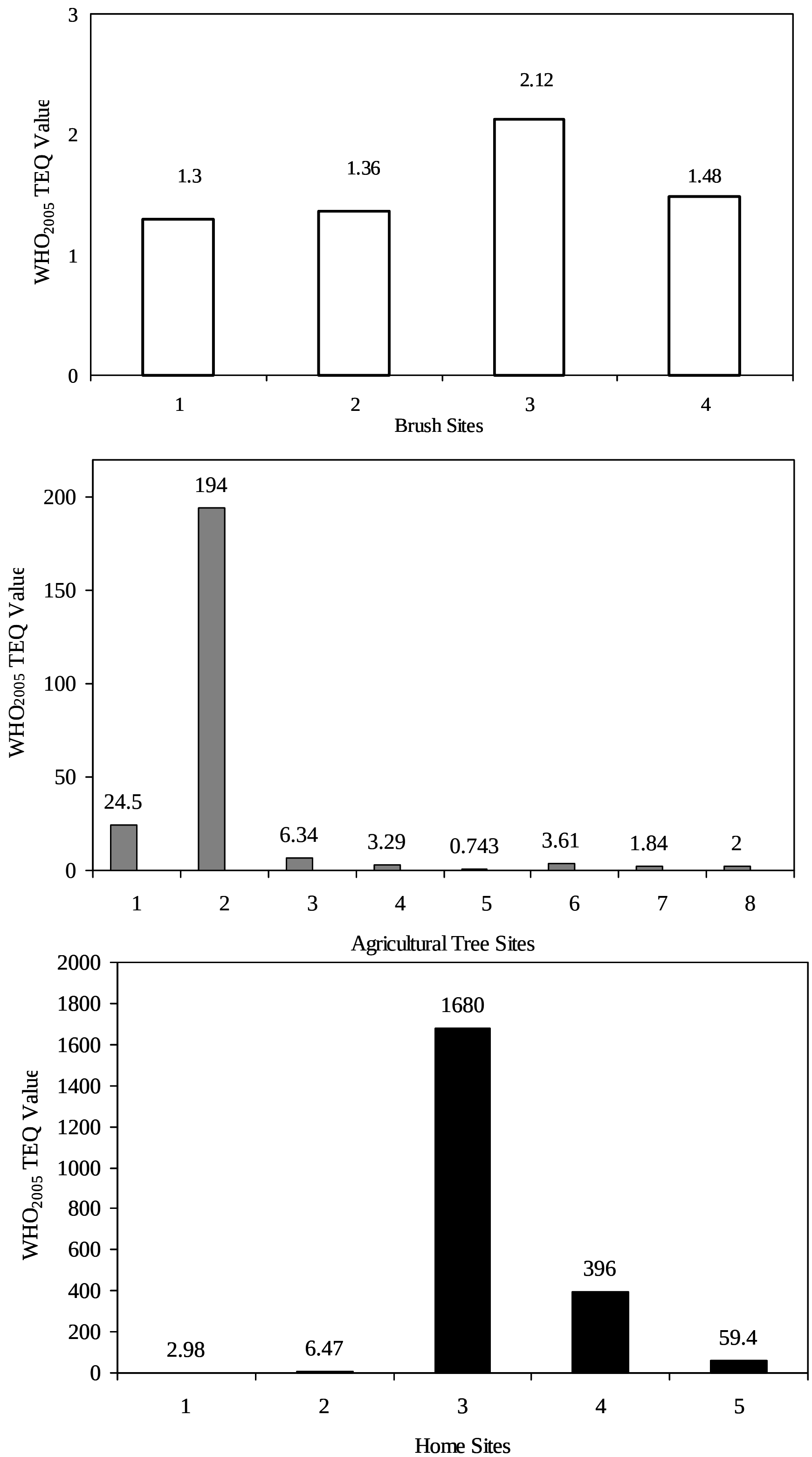

Figure 1. WHO TEF/TEQ values for sites characterized with brush vegetation (top), agricultural vegetation (middle), and burned homes (bottom). Note scale change.

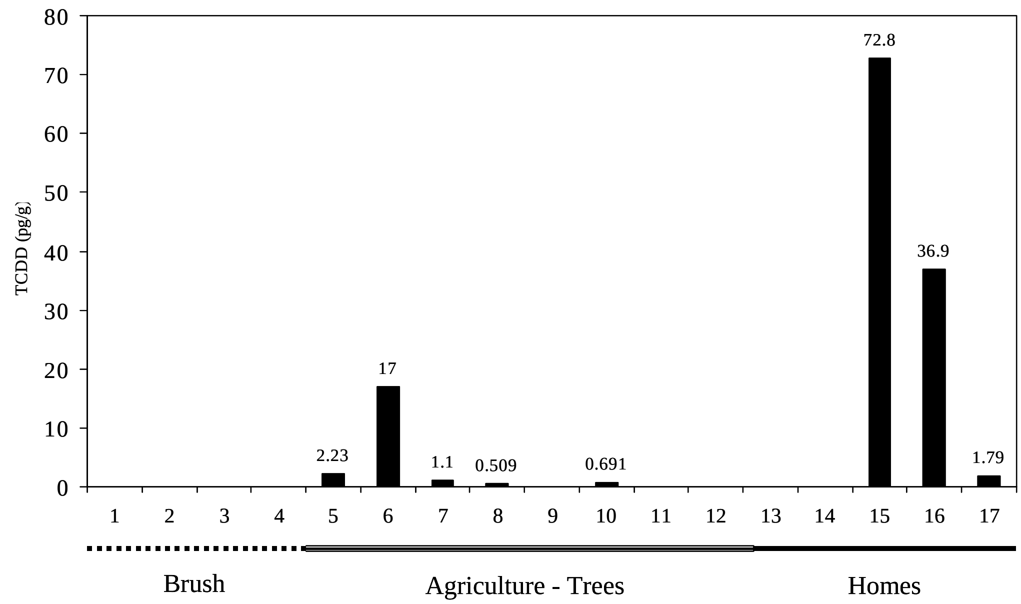

Figure 2. TCDD values were detected at eight of the sample sites with the production of this congener differing based on the type of vegetation and presence of homes.

Samples were collected using standard protocols for obtaining dioxin samples in the field. Stainless steel spoons, previously washed in a solvent and wrapped in aluminum foil until use, were used to gather the samples. Ash and soils were placed in glass jars that had been washed in the testing laboratory for our purposes. Shipping was done under chain-of-custody. The laboratory used Method 8290 for the analysis because the extractions procedures are more appropriate for this matrix.

We used the WHO_{2005} TEFs and counted nondetects as the actual detection limit. A few of the test results fell outside of the arbitrarily selected 15 percent window around the theoretical value. For these congeners, the peak is declared, "estimated maximum possible concentrations (EMPC)." For our study, EMPC results were counted as the EMPC value.

RESULTS AND DISCUSSION

PCDDs and PCDFs were detected in every site with the highest levels found in ash from homes burned by the fires. Table 1 shows the robust suite of congeners associated with burned homes. Sampling sites with mature avocado groves had the second highest levels of PCDD/F. Sites where the dominant vegetation was brush had the lowest.

The TCDD toxicity equivalent concentrations for each site are depicted in Figure 1. The TEQ values ranged from 1.3 to 1680 ppt (n=17; Median=3.29 ppt; Arithmetic Average=140.44 ppt). Samples 15 and 16, taken at a burned home in a rural area surrounded by trees, had the highest levels of TEQs at 1,680 ppt and 396 ppt, respectively. The agricultural sample from site 6, which was taken within an avocado grove, was third highest at 194 ppt. There were no homes burned at this site and no adjacent industry.

The generation of TCDD follows a similar pattern. TCDD was detected in 8 of the 17 samples with a range between 0.691 to 72.8 ppt (n=8; Median=2.01 ppt; Average=16.62 ppt). Figure 2 depicts these data. Based on our research, the high-end of the TEQ values exceeds the ranges reported in the literature indicating that higher values in the environment do not necessarily indicate industrial activity.

Median and mean levels in the literature for dioxin levels in the environment, whether from ambient levels or associated with fires, can be misleading given the range of variability revealed in our data set. Researchers commonly publish a median or average value for their data, without an indicatin of the variability in the data, which can lead to an erroneous interpretation of environmental data. Using our data for example, had we merely presented the average (16.62 ppt) or median (2.01 ppt) values for TCDD, we would have lost the importance of the sample with nearly 73 ppt.

Homes that have burned in these uncontrolled fires contribute comparatively large concentrations of dioxins and furans to the environment. Dioxin profiles (Table 1) show large differences in qualitative and quantitative values among samples in our data set. On a percentage basis, our data show characteristics similar to forest fires, which are dominated by OCDD and 1,2,3,4,6,7,8-HpCDD.

This study provides important data on the production of PCDD/Fs from forest fires with different vegetation and structures and suggests that the contribution to ambient levels from the southern California fires exceeds the levels commonly reported in the literature for forest fires. As demonstrated by studies on backyard burning, the PCDD/F levels in ash increase in the presence of other organic matter[1,2,3]. In the case of these southern California wildfires, not all fires are the same with respect to the generation of PCDDs and PCDFs.

Table 1. Full Congener Profiles of Sampled Sites with Burned Homes. Data in Parentheses Reflect Nondetected Levels at the Level of Sensitivity of the Sample.

Analyte	Site 13 pg/g	Site 14 pg/g	Site 15 pg/g	Site 16 pg/g	Site 17 pg/g
TCDD	(0.194)	(0.327)	72.8	36.9	1.79
1,2,3,7,8-PeCDD	0.752	(1.05)	530	162	10.8
1,2,3,4,7,8-HxCDD	0.819	1.24	1090	246	9.5
1,2,3,6,7,8-HxCDD	2.08	4.43	1940	303	14.8
1,2,3,7,8,9-HxCDD	1.82	2.98	1880	323	13.7
1,2,3,4,6,7,8-HpCDD	63.8	126	37700	6260	79.4
OCDD	626	1090	344000	47700	194
TCDF	0.715	(2.51)	4.89	4.27	18.9
1,2,3,7,8-PeCDF	0.689	2.5	21.8	10.1	47.8
2,3,4,7,8-PeCDF	0.883	3.06	47.3	19.8	51.5
1,2,3,4,7,8-HxCDF	0.9	4.22	170	55.7	83.6
1,2,3,6,7,8-HxCDF	0.889	3.56	102	42.3	70.9
2,3,4,6,7,8-HxCDF	0.995	2.82	165	60.8	42.2
1,2,3,7,8,9-HxCDF	(0.343)	1.47	62.2	14	19.3
1,2,3,4,6,7,8-HpCDF	5.88	16.2	2940	729	145
1,2,3,4,7,8,9-HpCDF	0.617	2.71	326	8235	27.7
OCDF	8.59	21.4	11800	2740	49.3

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