HISTORICAL AND PROJECTED SURFICIAL SEDIMENT CONCENTRATIONS OF PCDD/Fs AND PCBs IN THE LOWER PASSAIC RIVER, NEW JERSEY, USA

Steave H. Su[1] and Brent L. Finley[2]

1 Exponent, 420 Lexington Avenue, Suite 408, New York, NY, USA 10170
2 Exponent, 631 First Street, Suite 200, Santa Rosa, CA, USA 95404

Introduction

The Passaic River is a major tributary of Newark Bay, New Jersey, USA, which is in a region that has been impacted by nearly two centuries of industrialization and urbanization[1]. Elevated sediment concentrations of a variety of contaminants, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), petroleum hydrocarbons, and semi-volatile and volatile organic chemicals, in this region have been reported by several investigators[2]. The six-mile (9.7-km) section of the river from its junction with the Newark Bay is identified by the U.S. Environmental Protection Agency as the Passaic River Study Area (PRSA) for which a Remedial Investigation is underway to assess the extent of contamination and associated current and future health risks.

In order to assess potential future human health risks in the PRSA, it will be necessary to develop projected concentrations of chemicals in the surface sediments and edible biota. In the USEPA's recent assessment of potential future health risks in the Hudson River (New York)[3] it was assumed that PCB levels in surface sediments and fish would decline over the next 40 years at a rate of 50% reduction approximately every 10 years. This estimate was based on historical trends observed in sediments and biota from the Hudson River.

We have recently conducted a similar analysis for the PRSA. Studies from 1991 to 1995 have characterized the chronology of PCDD/F and PCB concentrations in the surface and subsurface sediments in the PRSA[2]. The database derived from these previous investigations consisted of nearly 20,000 data records from sediment cores collected from roughly 100 locations. The core samples provided estimated year of sediment deposition at various depths based on Lead-210 and Cesium-137 radiodating analysis[4]. This database provides a unique opportunity to describe the historical trends of the PCDD/F and PCB concentrations in the surface sediments and a basis to forecast the future concentrations.

Materials and Methods

Data records containing sediment PCDD/F and PCB concentrations and estimated year of deposition were obtained from the previous studies[2]. Scatter plots of log average (arithmetic mean) sediment concentration versus time of deposition were developed for each PCDD/F and PCB congener and regression analyses were then conducted to model the historical trend and estimate sediment concentrations in the future.

For the purposes of this analysis, the year 1955 was chosen as the peak year of maximum surface sediment concentrations for all PCDD/F and PCB congeners (see Figures 1-4), and a linear regression of the decreasing sediment concentrations from 1955 to 1995 (the most recent data) was then used to project continued decreases from 1996 to the future years.

Results and Discussion

Figures 1-4 illustrate the temporal surface sediment concentrations from the mid 1940s to the mid 1990s for select PCDD/F and PCB congeners. Figure 1 shows the 2,3,7,8-TCDD historical trend in the surface sediments (average concentration versus year plot); this figure clearly shows a trend of increasing surface sediment concentrations beginning in the 1940s, peaking in the mid-1950s, and a continual decrease to the most recent radiodated levels of approximately 1 ug/kg.

This trend is very consistent with the initiation of 2,3,7,8-TCDD generation by numerous industries in the 1950s, followed by a decline as a result of increasing environmental regulations and cessation of production of 2,3,7,8-TCDD-containing compounds. A regression analysis of the post-1955 decline indicates that 2,3,7,8-TCDD levels in surface sediments have declined by 50% every 8.4 years. This rate of decline is much faster than for all other PCDD/F and PCB congeners (Table 1) and suggests there might be little if any ongoing 2,3,7,8-TCDD input to the PRSA.

Figure 1. Historical Trend of 2,3,7,8-TCDD Surface Sediment Concentrations

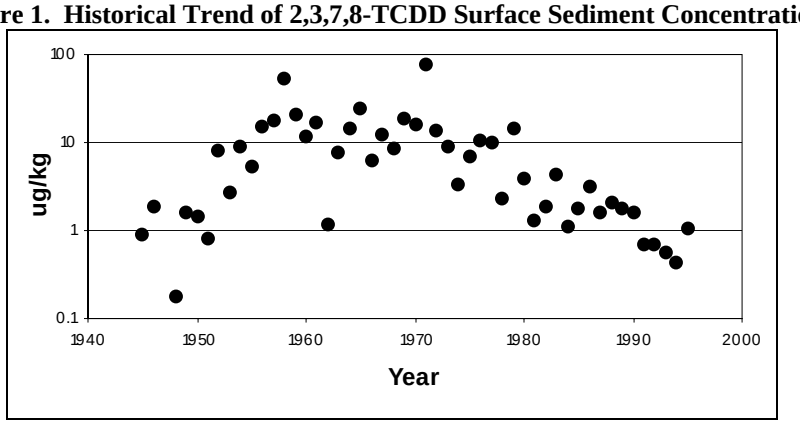

Figure 2 shows the 2,3,7,8-TCDF historical trend; this figure also shows an initial increase, a plateau and a subsequent decline. As indicated in Table 1, the rate of decline of 2,3,7,8-TCDF (halved every 15.2 years) is almost twice as long as that of TCDD. The data suggest that there may be ongoing 2,3,7,8-TCDF sources into the PRSA.

Figure 2. Historical Trend of 2,3,7,8-TCDF Surface Sediment Concentrations

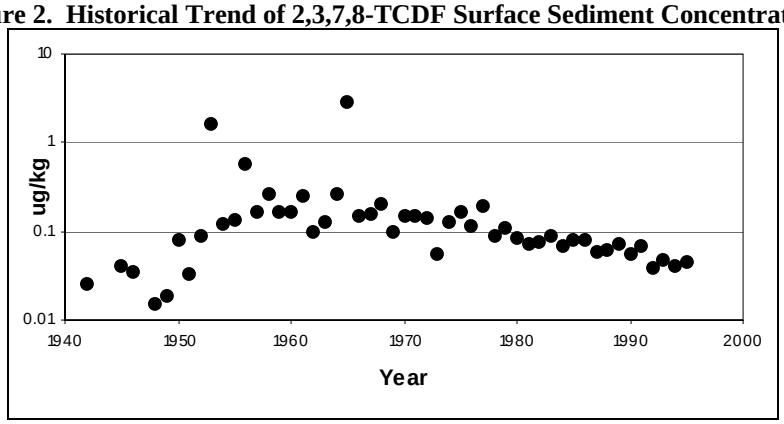

Figure 3 shows the OCDD/F historical trend; this plot shows the typical increase and plateau, but the subsequent rate of decline is slower than that of 2,3,7,8-TCDF. As shown in Table 1, 27.6 and 19.5 years were required for OCDD and OCDF concentrations (respectively) to decrease by 50%. Again, this may be suggestive of ongoing sources, which is not surprising. Unlike 2,3,7,8-TCDD, which is formed only via a few specific processes, OCDD and OCDF are relatively ubiquitous environmental PCDD/F contaminants that are generated by a variety of sources.

Figure 3. Historical Trends of OCDD and OCDF Surface Sediment Concentrations

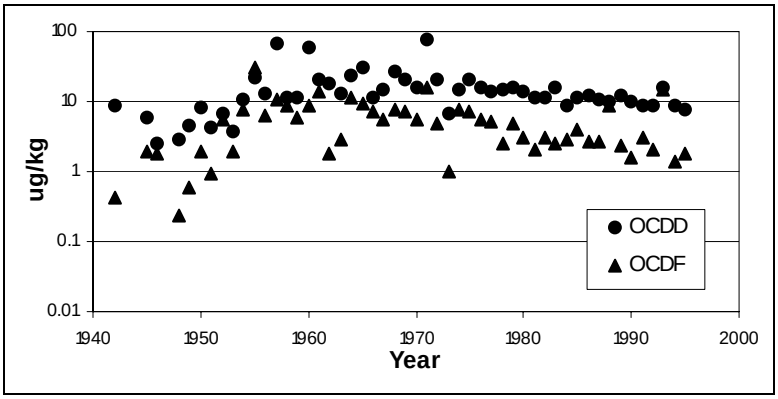

Figure 4 shows the surface sediment historical trend for several PCB congeners. These timelines are very different from those of the PCDD/Fs in that they show a peak in the mid-1950s, but very little subsequent decrease. As shown in Table 1, 16.5-35.7 years were required for the PCB congeners to decrease by half (far longer than the 10 year estimate used in the Hudson River analysis). These results seem to suggest that there are ongoing source contributions of PCBs in the PRSA.

Figure 4. Historical Trends of Select PCB Congener Surface Sediment Concentrations

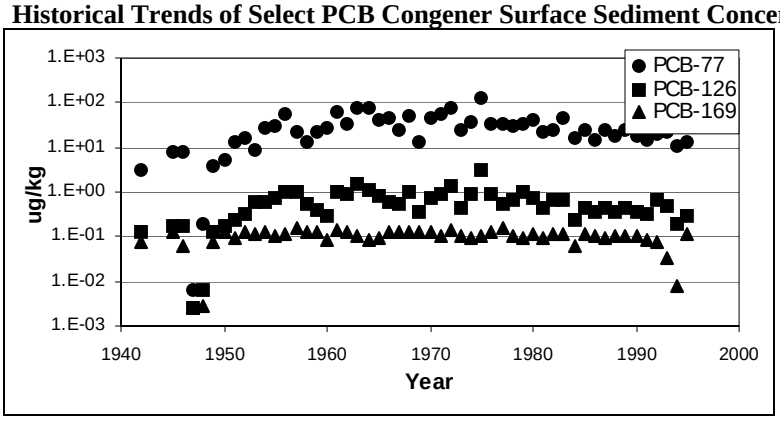

Table 1. Rates of Decline* for Surface Sediment PCDD/PCDF and PCB Congeners

Congener	*Years*	*Congener*	*Years*
2,3,7,8-TCDD	8.4	3,3',4,4'-TeCB (#77)	18
2,3,7,8-TCDF	15	2,3,3',4,4'-PeCB (#105)	16
1,2,3,7,8-PeCDD	13	2,3,4,4',5-PeCB (#114)	19
2,3,4,7,8-PeCDF	21	2,3',4,4',5-PeCB (#118)	17
1,2,3,7,8-PeCDF	24	2',3,4,4',5-PeCB (#123)	18
1,2,3,7,8,9-HxCDD	29	3,3',4,4',5-PeCB (#126)	21
1,2,3,6,7,8-HxCDD	20	2,3,3',4,4',5'-HxCB (#156)	20
1,2,3,4,7,8-HxCDD	29	2,3,3',4,4',5'-HxCB (#157)	20
1,2,3,7,8,9-HxCDF	18	2,3',4,4',5,5'-HxCB (#167)	24
1,2,3,6,7,8-HxCDF	29	3,3',4,4',5,5'-HxCB (#169)	24
2,3,4,6,7,8-HxCDF	21	2,3,3',4,4',5,5'-HpCB (#189)	36
1,2,3,4,6,7,8-HpCDD	22		
1,2,3,4,7,8,9-HpCDF	24		
1,2,3,4,6,7,8-HpCDF	25		
OCDD	28		
OCDF	20		

* Estimated number of years for 50% reduction.

The projected sediment concentrations presented here will ultimately be used in conjunction with a food web model to estimate potential future health risks to anglers. The temporal trends may also be used to evaluate the presence of ongoing chemical sources and to assess the merits of various remedial options.

References

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