ASSESSING DDT RISK IN A NEW JERSEY URBAN INDUSTRIALIZED WATERWAY

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STUDY AREA



Hudson River (Reference Area)

New York/New Jersey Harbor Area. Newark Bay Complex includes the tidal Passaic and Hackensack Rivers, Newark Bay, Arthur Kill, Kill van Kull and their tributaries.

SITE INFORMATION

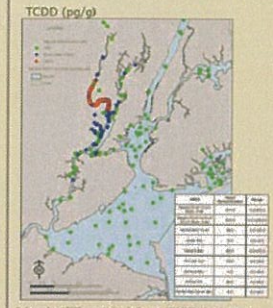
The Newark Bay Complex, an important economic, ecological and cultural resource, consists of 69 linear km (55 mi) of waterways, 389 km (242 mi) of shorelines, and encompasses 44 km² (17 mi²) of water.[1] Over 75 aquatic species utilize the area for feeding, breeding, and nursery habitat. Numerous bird species, including colonial wading birds, also use this area for feeding, breeding, and migratory stopovers. Portions of the complex have been designated significant habitat by the U.S. Fish and Wildlife Service.[2] While the public uses this area for recreational purposes, fish consumption advisories have been in effect since the mid-1980's due to the presence of dioxin, PCBs and chlordane.[3] In addition to providing significant habitat for fisheries, this area supports major shipping and maritime activities.

Situated on the southern shore of the tidal Passaic River in the highly industrialized city of Newark, New Jersey, the Diamond Alkali Superfund Site produced DDT and phenoxy herbicides beginning in the 1940's, as well as various other chemicals throughout its industrial history.[4] The herbicide manufacturing history included the production of > 2.1 million pounds (>400,000 gal) of Agent Orange during the Vietnam War.[5] Dioxin is a by-product of the phenoxy herbicides. An estimated 4 to 8 kg (~ 9-18 lbs) of 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD) was deposited into Newark Bay from this facility over a 40- year period, rendering the Diamond Alkali Superfund Site as the primary source of dioxin contamination to the Newark Bay Complex (NBC).[6] TCDD, in a sediment core from a mudflat adjacent to Diamond Alkali was measured at 5,200 pg/g in the top 15-24 cm (6 inches) with a maximum of 5,300,000 pg/g at 1.4-1.7 m (4.5-5.5 ft) depth. Octachloro-dibenzo-p-dioxin (OCDD), in the same core reached 8,340 pg/g in the top slice and 802,000 pg/g in the subsurface.[7] Numerous other organic and inorganic contaminants, in addition to polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) were detected above screening criteria,[8] but are not the focus of this analysis.

[1] Calculated using ArcView 3.3 GIS. [2] United Cont. [3] Achen et al. 1998, NJDEP 2005, [4] USEPA 1987, [5] House Energy Corp v. USA 1992, [6] Bopp 1998, [7] NOAA 2005, Panon 1985, [8] NOAA 2005

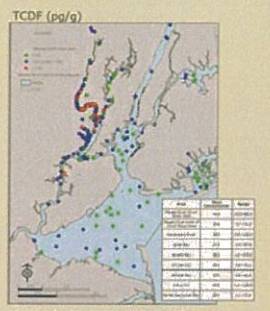
SURFACE SEDIMENT

TCDD (pg/g)



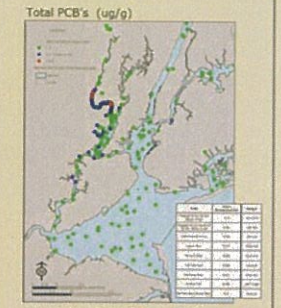
Surface sediment TCDD concentrations for the years 1990-2000. Highest mean and maximum concentrations were detected in the lower Passaic River. Concentrations tend to decrease with increasing distance from the Diamond Alkali facility. Mean surface sediment TCDD are about an order of magnitude higher in the Passaic River than Newark Bay, Hackensack River, or Arthur Kill and decrease another order of magnitude in the Upper Bay, Lower Bay and Kankari Bay. Maximum concentrations in the Passaic River are 1-2 orders of magnitude higher than elsewhere. Mudflat River average TCDD was the same as Jamaica Bay, but with a smaller variance.

TCDF (pg/g)



Surface sediment TCDF concentrations for the years 1990-2000. The spatial distribution pattern for TCDF was much less distinctive than observed with TCDD. Mean and concentration ranges were similar for the lower 10 km of the Passaic River and the Arthur Kill and there was less than 1 fold difference between all locations. Mudflat River average TCDF was most similar to Jamaica Bay.

Total PCB's (ug/g)

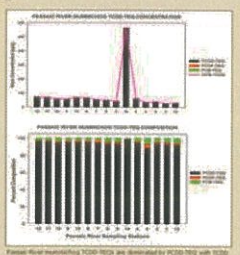


Surface sediment total PCB concentrations for years 1990-2000. Highest concentrations documented in the Passaic River. Concentrations tend to decrease as one moves further away from the Passaic.

PCDD, PCDF, AND PCB CONTRIBUTIONS TO TCDD-TEQ



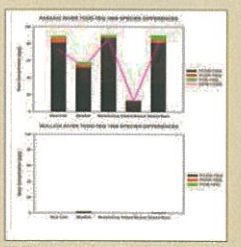
Ecological reference sampling stations in the Mullica River.



Passaic River monitoring TCDD-TEQs are dominated by PCDD-TEQ with TCDD as the main contributor to PCDD-TEQ. Greater than 99% of the TCDD-TEQ at station 14 was attributable to PCDD-TEQ. PCDF and PCBs contribution to overall TEQ was elevated at all the other stations relative to Station 14.

Ecological sampling stations along the 14 km study area of the lower Passaic River, Diamond Alkali = Station 14.





PCDD-TEQ contribute >90% to the total TCDD-TEQ in the Passaic River regardless of species analyzed. PCDD comprised 99% of the PCDD-TEQ and between 90% and 96% of the TCDD-TEQ for all species evaluated. These trends did not hold for the same species collected from the Mullica River. PCDFs, including TCDD, were more than half of the TCDD-TEQ in the mullet, blue crab and invertebrates. PCDD-TEQ contribution to TCDD-TEQ was 100% but <70% for bluefish and striped bass.

TCDD-TEQ, on a concentration basis, was orders of magnitude higher across the five species of biota and invertebrates examined in the Passaic River compared to the Mullica River. TCDD in Passaic River blue crab hepatopancreas (not shown) was three times higher than that of soft tissue (shown).

METHODS

NOAA developed a Newark Bay Watershed Database and Mapping Project by compiling sediment chemistry, tissue residue and bioassay results (http://response.restoration.noaa.gov/cpr/watershed/watershedtools.html) for a variety of contaminants and species. This database consists of numerous studies conducted between 1985 and 2003 by academics, state and federal agencies and private companies. As a consequence, various sampling and analytical methods were employed with different approaches to sediment segmentation schemes, tissues and organisms sampled, and chemicals analyzed.

Our original intent was to conduct an analysis of a subset of these data to determine the spatial distribution of PCDD, PCDF and PCBs in sediment and tissue throughout the NY/NJ Harbor area, to evaluate the contribution of each to tissue TCDD-toxic equivalences (TEQs), and to assess risk to aquatic and piscivorous biota. Data constraints limited our ability to conduct as broad a geospatial analysis as planned. We alternatively analyzed sediment contamination harbor-wide, but narrowed our focus to the Passaic and Mullica Rivers for relative contribution, concentration, and risk analyses of TCDD-TEQ to aquatic and piscivorous biota.

2,3,7,8- TCDD and 2,3,7,8-tetrachlorodibenzo-p-furan (TCDF) concentrations in surface (general range of 2 to 15.24 cm) and subsurface sediments were determined throughout NY/NJ Harbor to explore mean and range of concentrations as well as spatial distribution.

To assess risk from organochlorines to aquatic biota, TCDD-TEQs were calculated by multiplying individual congeners of PCDD, PCDF and PCB by their respective fish Toxic Equivalency Factors (TEFs) and summing the TEQs.[9] Diamond Alkali remedial investigation ecological sampling data collected between 1995 and 2001 over a 10 km (6 mi) stretch of the Passaic River were used to examine the degree of PCDD, PCDF, and PCB contamination in numerous aquatic species and the relative contribution of each to the total TEQ.

The 1999 dataset consisted of 15 Passaic River stations and three reference stations in the Mullica River. Station 14, adjacent to the Diamond Alkali facility, is located about 3.2 km (2 mi) upstream from the downstream edge of the 10 km study area. Whole body tissue analysis was conducted for the three fish species while soft tissue was analyzed for the invertebrate species. Crab and mussel data were reported as one value per station, representing composites of 3 cages. Mummichog data reported as one value per cage with 3 cages per station.[10]

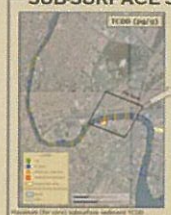
Ten species of aquatic biota collected from the Passaic River (1995, 1999-2001) and Mullica River (1999-2000) were used to generate TCDD-TEQs (as described above) for the risk analyses. Tissue residues were compared to species-specific toxic reference values (TRVs)[11] TRVs reported as dry weight liver concentrations were converted to wet weight by dividing by 3.7[12] to estimate risk to piscivorous wildlife. TCDD-TEQs were also calculated on aquatic tissue data using avian and mammalian TEFs. These tissue residues were compared to Canadian guidelines developed for the protection of birds and mammals that consume aquatic prey.[13]

[9] Van den Berg 1998, [10] NOAA 2003, [11] Cook et al. 2003, Prince and Cooper 1995, Black et al. 1996, [12] Illinois personal communication 2003, [13] Canadian Council for the Environment 2005

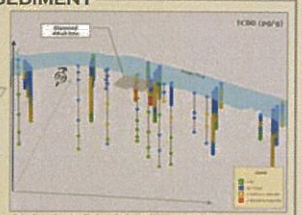
CONCLUSIONS

- Concentrations of TCDD-TEQ were up to four orders of magnitude higher in the Passaic River biota compared to Mullica River biota.
- Mummichogs in the Passaic River show maximum contribution to TCDD-TEQ to be from PCDD adjacent to Diamond Alkali.
- PCDD-TEQ dominated TCDD-TEQ in Passaic River biota with TCDD comprising 99% of the PCDD-TEQ and >96% of the TCDD-TEQ.
- In the Passaic River, the proportion of PCDD, PCDF and PCB to TCDD-TEQ was independent of species collected, size of home range or trophic status.
- Results for Mullica River PCDD, PCDF, PCB contribution to TCDD-TEQ present a different pattern reflecting a system with much lower concentrations of TCDD. Species home range and trophic status likely influence the observed patterns. We hypothesize that Jamaica Bay biota might exhibit similar patterns to Mullica River given similar surface sediment PCDD, PCDF, and PCB concentrations.
- TCDD-TEQ bioaccumulation in Passaic River sediments pose a risk to fish, birds and mammals.
- Future studies should be designed in the Greater Newark Bay Complex to analyze sediments and biota for PCDD, PCDF and coplanar PCBs to evaluate concentration gradients, calculate TCDD-TEQs, and assess risk to ecological receptors.

SUB-SURFACE SEDIMENT

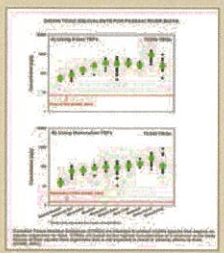


Absolute (for core) subsurface sediment TCDD concentrations for the years 1990-2000. Shows maximum concentrations adjacent to Diamond Alkali facility.

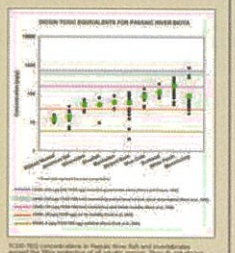


Subsurface sediment profile shows distribution of TCDD in cores adjacent to the Diamond Alkali facility indicating pre-release conditions below maximum concentrations.

ECOLOGICAL RISK ASSESSMENT



TCDD-TEQ concentrations in Passaic River aquatic prey exceed PCB and PCDD/PCDF guidelines to protect all piscivorous birds and mammals. In contrast, TCDD-TEQ concentrations in Mullica River exceed the avian and mammalian guideline only for bluefish and striped bass (not shown). CCME guideline shown is sum of PCB-TEQ and PCDD/F-TEQ guidelines. Additive model assumed. [14]



TCDD-TEQ concentrations in Passaic River fish and invertebrates exceed the TRVs protective of all aquatic species. They do not exceed TRVs developed for relatively insensitive species. In contrast, in Mullica River, biota do not exceed any of the TRVs including the 1 pg TCDD-TEQ/g egg for subdivet effects. This analysis assumes liver and whole body concentrations similar, [15] and lipid concentrations in tissue and eggs comparable. [16]

[14] Newsted et al. (2005) reports only of liver in fish (bluebill) as EC. [15] Hoffman et al. (1996) reports ratio of egg to adult female as 0.68

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Newark Bay Study Area
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