RESEARCH PROGRAM

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Research at Crab Orchard National Wildlife Refuge

Hazardous Waste Research and Information Center
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HWRIC began supporting investigations into the contamination problems at Crab Orchard National Wildlife Refuge in 1988, shortly after the refuge was placed on the Superfund National Priorities List. The Remedial Investigation/Feasibility Study (RI/FS) to characterize the site and propose cleanup strategies was completed in 1989. The RI/FS listed the Area 9 Landfill (or Sangamo Landfill), the site of a former transformer reclamation operation, as the most contaminated site and the first scheduled for cleanup.

Center support for investigations at the refuge provides an opportunity to follow a Superfund cleanup and collect information about environmental contamination before, during, and after the remediation. Cleanup has not yet begun but is planned for the near future. Descriptions of HWRIC-funded research at the refuge follows. Results of completed projects have been published in the Center's Research Report series.

Determination of Animal Hazards from PCB-Contaminated Air and Soil Samples from Crab Orchard Using Planaria and Rat Bioassay Systems

This investigation uses bioassay methods for hazard identification, hazard characterization and dose-response assessment of various matrices associated with the contaminated landfill in Crab Orchard National Wildlife Refuge. The site is on the Superfund National Priorities List, access is restricted, and excavation-incineration is proposed as the remediation measure. High polychlorinated biphenyl (PCB) concentrations have been documented in soil and air at the site and this study seeks to determine the effects these contaminants have on life functions of the biota. As part of this work, standard bioassays are being developed into an integrated system to yield a more complete picture of the impact of environmental chemicals.

Air, surface soil and debris, and subsurface soil samples were collected from two locations, a control site and the contaminated landfill. Analyses revealed differences in proportions of the types of chlorinated compounds between the three sample types. Some form of slow dechlorination appears to be occurring in the moist, semi-anaerobic subsurface soils where there was a higher proportion of lightly chlorinated PCBs than anticipated. As expected, more lightly chlorinated PCBs dominated in the air samples, but the dust samples, wherein moderately chlorinated congeners dominated, contained fewer lightly chlorinated congeners than either air or subsurface soil. Specific congener PCB analyses, polychlorinated naphthalene (PCN) analyses, and polychlorinated dibenzofuran (PCDF) analyses have been completed. No organometallics were detected in the samples from either site.

Extracts of each of the sample types were acutely toxic to freshwater planaria (*Dugesia dorotocephala*). Loss of consciousness occurred within 24 hours at some dose levels, and complete head loss occurred within 6 days at moderate doses. The extracts were more toxic than comparable doses of Aroclor 1254 and the deformed heads were similar to responses to Aroclor 1242. The air extract caused depression of dopamine at 1 day and 1/2 of the ineffective dose of the soil extract; however, by day 6, dust and soil extracts depressed dopamine to a greater extent than the air extract.

Initial studies with young (prepubertal) female rats have indicated that soil extracts induce estrous and

liver enzymes, depress serum thyroxine levels and, at higher doses, cause adrenal gland enlargement. These are typical responses to chlorinated aromatic compounds and the relationships among the different effects provide insight into which chlorinated aromatics dominate. There appear to be very definite qualitative as well as quantitative differences between the health effects of contaminants in the air, dust, and soil extracts.

Recently, attention has been focused on hormone disruption in wildlife populations by environmental chemicals. Effects of hormone disruption seen in wildlife include decreased sperm levels and sex reversal. Testing done as part of this study will further our understanding of the health effects of chlorinated compounds in the environment.

This work led to the submission of a proposal to the National Institute of Environmental Health Sciences (NIEHS) to 1) use these extracts and soil samples as a model for testing non-combustion remediation processes, and 2) to determine the relative toxicities of the starting material to the 'remediated' materials. Also, the Agency for Toxic Substances and Disease Registry (ATSDR) has invited a proposal to develop toxicity test batteries and risk assessment methods for environmental chemical mixes.

August 1992-June 1995
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Starlings as Avian Model and Monitors of Remedial Effects at Crab Orchard National Wildlife Refuge

The 1988 Remedial Investigation of Crab Orchard National Wildlife Refuge (CONWR) identified seven contaminated areas within the refuge that posed a potential risk to wildlife and recommended remediation of these sites. Exposure and effects data are available at some of these sites for mammalian species, however, only limited data are available for avian species. Preliminary studies revealed statistically significant accumulations of contaminants and effects in starlings (*Sturnus vulgaris*) nesting at one of these identified sites. The goal of this project is to provide pre-remediation base-line exposure and effects data on an avian model, the starling, and to provide a benchmark for assessing the effectiveness of remediation.

The project objectives are 1) to measure polychlorinated biphenyls (PCBs) and selected metals to determine exposure, and physiological and biomarker effects in starling chicks and adults, and 2) to monitor nest attentiveness and abandonment behavior of adult starlings from four CONWR sites identified as posing moderate to high risk to wildlife. Prior to the beginning of the nesting season, 12 starling nest boxes will be located at each of four contaminated sites and at two reference sites. During the breeding season, starling productivity (eggs/nest, chicks/nest) and adult nest attentiveness behavior (nest abandonment, number of chicks surviving to 15 days) will be monitored. Adults and chicks at 15 days post-hatch, will be collected for contaminant and biomarker analyses. Differences in contaminant body burdens and biomarker responses in chicks and adults, and adult behavior will be compared among all sites and between reference and remedial sites.

Results of this project will provide regulatory authorities with exposure and effects data not currently available for avian species utilizing contaminated sites at CONWR.

This project began in June 1994. Nest boxes will be constructed in fall of 1994 and installed at the study sites before nesting season. Data collection and analysis will be conducted during spring and summer 1995. The project is scheduled for completion in October 1995.

June 1994 - October 1995
Richard Halbrook and Alan Woolf
Cooperative Wildlife Research Laboratory
Southern Illinois University

Seasonal/Temporal and Spatial Patterns of PCB Contamination of Fishes in Crab Orchard Lake

Concentrations of PCBs in three age groups of six fish species (largemouth bass, channel catfish, common carp, bluegill sunfish, white crappie, and gizzard shad) were studied at three sites in Crab Orchard Lake in the spring, summer, and fall 1986-1990. PCB concentrations and lipid levels in the fish were usually highest in fall, intermediate in spring, and lowest in summer. Channel catfish, common carp, and largemouth bass often had PCB concentrations exceeding the FDA action level for edible tissues (2.0 mg/kg). Fish collected in close proximity to the Sangamo dumpsite (a source of PCB contamination) were often significantly more contaminated than those collected at other sites.

Results of this study indicate that with respect to PCB monitoring, channel catfish and largemouth bass are excellent species for monitoring PCBs, and that channel catfish are the most likely to be contaminated. Collections should be restricted to harvestable-size fish, and PCB analyses should be conducted on individual fish rather than composites. Collections should be taken in the fall when lipid and PCB levels would tend to be at their highest. The substantial decline in PCB contamination concomitant with reductions in lipid levels in fish from spring to summer indicates that a successfully completed cleanup of a point-source of PCB contamination could show relatively rapid results within a fish community. High PCB burdens appear to not be permanently sequestered in fish but rather require continual exposure in the environment. Seasonal public health advisories may be possible, because fish collected in the summer pose no health risks. If an all-seasons advisory is issued then only PCB data obtained from fall collections of harvestable-size fish should be used.

Christopher Kohler and Roy Heidinger
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Southern Illinois University
RR-072 (available December 1994)

Air Concentrations of Polychlorinated Biphenyls and Metals at Crab Orchard National Wildlife Refuge

Airborne PCB and metal levels were monitored at the Crab Orchard National Wildlife Refuge. Background total PCB concentrations averaged 0.19 ng/m^3, with higher total PCB concentrations monitored during the summer (0.24 ng/m^3), and lower total PCB concentrations monitored in the winter (0.10 ng/m^3). PCB-contaminated surface soils at the Olin site averaged 9.9 ng/m^3, while the adjacent landfill site (deeper soil contamination) averaged 611 ng/m^3 for total PCB concentration. Within each site total PCB concentrations increased with higher air temperatures. PCB congener-specific determinations revealed a unique PCB signature for air over the landfill, characteristic of more abundant highly chlorinated congeners in comparison to 'aged' PCBs. This unique signature did not exist in air samples collected at the Olin site, suggesting a more complete degradation of the highly chlorinated PCBs at that site. The landfill signature confirmed that air samples collected at the background site were occasionally impacted by the PCB-contaminated landfill due to northwest winds.

The air concentration of particulates and 18 metals, including many identified as soil contaminates, provide no indication of a local source of contamination. Particulate concentrations (fine and coarse) were highest in the summer (29.3 ug/m^3), and the lowest in the winter (3.2 ug/m^3). Spatial and temporal variability of particulate and metal concentrations could be attributed to changes in air masses, site exposure, and condition of the soil.

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RR-063 (available December 1994)

Levels of PCBs and Trace Metals in Crab Orchard Lake Sediment, Benthos, Zooplankton and Fish

Concentrations of trace metals and PCBs in fish, zooplankton, macrobenthos, sediment, and water were measured at 11 sites throughout Crab Orchard Lake, including one site near an abandoned dumpsite of a former electrical transformer manufacturing facility (Sangamo). PCB levels at the Sangamo site for the biotic and abiotic components were considerably higher than the other sites. FDA action levels for PCBs in edible fish tissues (2.00 mg/kg) were exceeded in 38% (17/45) of the fish fillets from various species collected at that site. Little relationship existed between fish age or size and PCB concentrations. Common carp and channel catfish had higher PCB levels than other species tested.

Trace metals were low in fish and other components analyzed and were comparable to literature values for the midwestern United States. Mercury was the only trace metal to exhibit biomagnification and to have a significant positive relationship with age or size of fish. Omnivorous species contained higher levels of the other trace metals.

When the cleanup of the Sangamo dumpsite takes place, the database established from this and other studies at the refuge will provide baseline data for comparison with post-cleanup data.

Christopher Kohler, Roy Heidinger, and Todd Call
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RR-043

Ecotoxicological Evaluation of Area 9 Landfill at Crab Orchard National Wildlife Refuge: Biological Impact and Residues

Polychlorinated biphenyl (PCB) and lead residues were investigated in soil and biota at Crab Orchard National Wildlife Refuge and related to biological effects. PCB levels in soils from the Area 9 Landfill ranged from 25 to 7,300 mg PCB/kg soil (wet weight) and lead concentrations ranged from 40 to 5,000 mg lead/kg soil. PCBs were rapidly mobilized from the soil into the terrestrial food chain as evidenced by high residue levels in adult June beetles, caged house crickets, and white-footed mice. Evidence from this study indicates that inhalation exposure may be more important than indicated in other exposure assessments. Bioaccumulation of lead was not observed in invertebrates, but was observed in the white-footed mice.

Invertebrate abundance and biomarkers were evaluated for toxic response to soil contaminants. The control site and Area 9 Landfill had similar abundance levels, family richness, and diversity for the five terrestrial invertebrate families studied. Biomarker analysis in honeybees and house crickets did not reveal significant adverse effects of PCBs or lead. Soil criteria for PCBs and lead indicate that biota at lower trophic levels can occupy areas of higher levels of contamination than biota at higher trophic levels that are dependent on contaminated biota as a food source.

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RR-062

Other HWRIC-sponsored research has examined contamination problems in the Calumet, Rockford, and East St. Louis areas; evaluated remediation technologies; explored waste reduction technologies and techniques; and identified the risk associated with contaminated sites and their cleanup. A list of completed project reports available from HWRIC can be obtained by calling the Center's clearinghouse at (217)333-8940.