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Defense Date: April 24, 2012

Title: Identification, Quantification and Distribution of Polychlorinated Biphenyls (PCBs) in sediments of the Rappahannock and York River Watersheds

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ABSTRACT

This study is intended to contribute to an understanding of water quality in a portion of the Chesapeake Bay: the Rappahannock and York watersheds. My PhD dissertation proposal is to identify, quantify, and determine the distribution of polychlorinated biphenyls (PCBs) in river sediments. These watersheds are adjacent to each other and are sub-watersheds of the Chesapeake Bay watershed (VA DCR, 1993). Both are in the Piedmont and Coastal Plain physiographic provinces. In general, topography and land use patterns in both watersheds are similar. The Rappahannock watershed is more densely population and contains more wastewater treatment plants than the York watershed. The York River watershed is sparsely populated and contains more factories such as paper mill, and refinery.

PCBs are a group of man-made chemicals. The basic chemical structure of PCBs (see figure 2) consists of two-ring aromatic hydrocarbon biphenyls (Manahan, 1994). By substituting 1 to 10 chlorine atoms at specific positions on the aromatic biphenyls, over 200 different compounds can be produced. In general, PCBs are chemically and thermally stable. PCBs with three or more chlorines are more toxic, bioaccumulative and resistant to environmental degradation (Barbalance, 2003). Properties of PCBs with three or more chlorines attached to benzene rings include low vapor pressure, nonflamability, high dielectric constants, and low water solubility (NRC, 2001). As the degree of chlorination increases, low water solubility and volatility decrease. PCBs are probable carcinogen.
(www.pollutionissues.com, 2/2009), and the toxicity and bioaccumulation of PCBs increase. Environmental Chemistry (http://environmentalchemistry.com 2/2/09) reports that PCBs with higher (i.e. three or more) chlorine contents are less biodegradable than those with less chlorine. Those PCBs with more chlorines have the propensity to bioaccumulate in the environment.

The manufacture and industrial uses of PCBs in the United States date back to 1929. With few exceptions (e.g. microscopic oils, electrical transformers and capacitors), the Toxic Substance Control Act of 1976 banned the use of PCBs (NRC, 2001). About 700,000 tons of PCBs were manufactured between 1929 and 1977. The major uses of PCBs include electrical

insulating-coolant fluids in electrical transformers and capacitors, flame retardants, hydraulic fluids, surface coating materials, pesticide extenders, plasticizers, lubricants, adhesive, dyes, ink and dye carriers, carbonless copy paper, paint additives, sound damping materials, freezer and refrigerator motors, fiberglass, foam rubber, water proofing materials, impregnation fluids, and chlorinated solvents. Roughly 200 chemical processes can produce PCBs as by-products.

Land use patterns in and adjacent to a watershed affect the chemical quality and composition of natural waters such as rivers, lakes, streams, ponds, etc. (Hem, 1989). Waste disposal or waste management sites such as incinerators, waste-to-energy plants, landfills, composting, and atmospheric deposition may add solutes to natural waters. The rates of water movement, as well as solute addition to and circulation in natural waters, are affected by agricultural cultivation of forested land, land development and construction, operation and maintenance of structures and facilities such as dams, bridges, factories, refineries, smelters, petroleum storage sites, and wastewater treatment plants. A land use summary map for both watersheds was constructed.

It is hypothesized that PCB-contaminated sediments in some parts of both the Rappahannock and York watersheds are excessive and that there is a need for remediation. Identification of "PCB hot spots" is a necessary procedure prior to a determination as to whether or not remediation of PCB-contaminated sediment is warranted. Remediation of PCB-contaminated sediment from a river system can improve water quality. Laminar flow conditions and low energy stream environments are conducive to the deposition of fine-grained sediments. It follows that contaminated sediments are anticipated to accumulate within certain low flow sections of the proposed study areas (NRC, 2001).

The objective of this dissertation is to determine if any parts of York and Rappahannock watersheds need remediation. This study proposes to determine if significant concentrations of PCB contaminants exist, and if so, to determine the extent of contamination. To this end, I propose to identify and quantity the concentrations and distributions of PCBs in the Rappahannock and York watershed sediments. This study designed and used systematic grid sampling method. Systematic sampling was used to collect statistically representative sediment samples from the York and Rappahannock River watersheds. United States Environmental Protection Agency (U.S. EPA) method 1668A was used to chemically analyze each sediment sample for PCB homologues and total PCBs. Nonparametric statistical methods and personal computers were used to statistically analyze concentrations of PCBs in sediment samples. Results from statistical analyses and interpretation of the data for both watersheds follow.

All sediment samples collected from the York River and the Rappahannock River detected total PCBs. Concentrations of total PCBs detected in sediment samples from the York River watershed ranged from 30.8 pg/g to 1170 pg/g. Concentrations of total PCBs detected in sediment samples from the Rappahannock River watershed ranged from 5.78 pg/g to 3120 pg/g. Within the York River watershed, about 74% of total PCBs detected in sediment samples collected in the vicinities of industrial facilities, 12% of total PCBs detected in sediment samples from mixed land uses area, and 9% in rural/agricultural areas. Within the Rappahannock River watershed, 49% of total PCBs detected in sediment samples came from sample sites in urban/commercial areas, 26% from mixed land use area, 11% and 10% from industrial and rural/agricultural areas respectively. Median total PCBs detected in the Rappahannock watershed was 60.75 pg/g, and the median total PCBs detected in the York River watershed

was 153.7 pg/g. There are about four “Hot Spots” containing total PCBs concentrations in excess of 500 pg/g in the Rappahannock River watershed, and roughly three total PCB “Hot Spots” in the York River watershed. Detailed site characterization at each “hot spot” is strongly recommended.

Toxic Substance Control Act (TSCA) definition of PCB-contaminated materials is 50 mg/kg. In other words, regulators would normally considered concentrations of PCBs in sediment below 50 mg/kg as “no action level”. Total PCB concentrations detected in sediment samples for this research were in the pictogram range and below 50 mg/kg. Results from this investigation should be used as a basis for additional investigation or site characterization of “hot spots” as opposed to direct remediation of PCB-contaminated sediments at “hot spots”.