

**Corbicula Active (ABM) Biomonitoring and Passive (POM) Chlordane Monitoring  
in the Anacostia River Watershed (MD).**

Final Report to the DC Water Resources Research Center

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**Abstract:**

This 2010 research project focused on the high chlordane contamination found in upper Sligo Creek Park (MD) of the Anacostia River watershed (MD/ DC), using active biomonitoring (ABM) with translocated freshwater clams *Corbicula fluminea*, passive monitoring with polyoxymethylene strips (POM) and fish and sediment analyses. At the most downstream site (SCF) the sediment chlordane was 4X the Canadian standard for protection of wildlife. Technical chlordane levels in Blacknose Dace minnows and in ABM clams at four weeks were statistically equal and exceeded (5X) the US Fish and Drug Administration (USFDA) standard for fish consumption. Measured chlordane increased significantly (1.5X) over two to four weeks deployment for both ABM and POM. Technical chlordane monitored by ABM was higher than by POM but after adjusting for wet vs dry weight more chlordane was adsorbed by POM. Chlordane concentration in SCF sediment organic carbon was similar to tidal Anacostia sediment. No difference in chlordane was found among small and large clams. ABM chlordane was lower at five sites upstream from SCF but the USFDA standard was exceeded at all sites but one. Four Sligo Creek sites above Route 193 (SC1, SC2, SCB, SCH) had almost no minnows and ABM clams initially died at site SCB. High chlordane by ABM was accompanied by high heptachlor epoxide and dieldrin which were the only other pesticides detected.

**Introduction:**

The freshwater Anacostia River is a tributary of the freshwater Potomac River and has a 126 square mile watershed in DC and MD. Although the Anacostia is currently the subject of major plans to address stormwater, sediment, nutrients and trash (ARP 2010) it is better known for its toxic pollutants that rate it one of three Areas of Concern in the USEPA/NOAA Chesapeake Bay Program (Chesapeake Bay Program 1999) and listed among America's 10 worst rivers. Over 60% of the resident fish have tumors (Pinkney et al. 2000) and the sediment is toxic, lacking many benthic species found in the nearby Potomac (Phelps 1985, Phelps 1993). The Anacostia has a fishing advisory for PCBs and pesticides (DC Department of Health 2006) with TMDLs for PCBs and Trash and is developing programs for control of stormwater, nutrient and suspended sediment loads (ARP 2010).

The 10 km tidal Anacostia River was extensively studied from 1999 to 2002 by an EPA/NOAA partnership (AWTA 2004), which considered contaminated tidal sediments as the major source of fish and benthos contamination (SRC 2000, NOAA 2002, AWTA 2004, EPA 2009). However the Anacostia Restoration Plan (NOAA 2002, ARP 2010) which is based on the NOAA database does not include data on toxics from the free-flowing Anacostia urban and industrial watershed.

Active biomonitoring from 1999 to 2010 used iterative active biomonitoring (ABM) where freshwater local *Corbicula* clams were translocated to 52 Anacostia watershed sites were analyzed for EPA Priority Pollutants including 18 polycyclic hydrocarbons (PAHs), 28 polychlorinated biphenyl congeners (PCBs), 6 Aroclors, 21 pesticides, and five metals (Cd, Cr, Cu, Fe, Pb) plus technical chlordane, percent water and percent lipid. This ABM study identified sections in five of 12 Anacostia subwatersheds with PCB, chlordane and PAH totals exceeding those found in the tidal Anacostia and also USFDA standards for fish consumption (Phelps 2011).

In addition to fish, clam and ecosystem contamination, polluted sites in the free-flowing watershed could be sources of the tidal Anacostia contaminated sediments. Organic contaminants such as PAHs, PCBs and pesticides are transported by association with suspended sediment particles, and particles from runoff have been found with much higher pesticide concentrations than consolidated sediments due to short-term mixing disequilibria (Bergamaschhi et al. 2001). The recent Anacostia Restoration Plan (ARP 2010) suggested watershed contaminants would be controlled as a result of stormwater control. However this could not apply to toxics from ongoing point and legacy sources of PCBs, PAHs and Chlordane in watershed streams.

Water contaminants can be measured both directly and indirectly. Direct water measurement of low levels of toxic contaminant is the best but also difficult and expensive. Indirect or passive samplers use accumulators containing a lipophilic solvent like hexane or a solid like polyoxymethylene over a period of time. Active biomonitoring uses bioconcentration over time by living organisms (often molluscs) either in situ or translocated. Active and passive monitoring have different purposes and can give different results (El-Shenawy et al. 2010). Passive indirect monitoring can be easier, used under more circumstances and related in the laboratory to contaminant concentrations in water. Active biomonitoring requires living organisms that have limits but gives information on actual bioavailability and life-stage sensitivity under environmental variables such as salinity, temperature and suspended organic material including additional sources of contaminants such as particulate food (Phelps 1979, Phelps et al. 1985a, Phelps et al. 1985b, Phelps and Mihursky 1986, Phelps and Hetzel 1987, Phillips 1987.) Active biomonitoring with molluscs has been used worldwide for monitoring of toxic pollutants (Crawford and Luoma 1993, Colombo et al. 1995, DeKock and Cramer 1995, Chase et al. 2001).

Sligo Creek is a large subtributary of the Northwest Branch which in turn is 42% of Anacostia river flow (Fig. 1). Complete ABM EPA Priority Pollutant scans of Sligo Creek in 2007 and 2009 found chlordane as the major contaminant, with levels increasing going upstream to the Main Branch site SCF (Fig. 1, Fig. 2) (Phelps 2008, Phelps 2010). Chlordane is a complex manmade pesticide once used for termite control and banned since 1988. Chlordane toxicity includes neurological effects and is termed a PBT (Persistent Biological Toxic) that accumulates in animal tissue and increases up the food chain, with toxic environmental effects. High chlordane in Sligo Creek was accompanied by high heptachlor epoxide and dieldrin. Current plans for Sligo Creek do not address toxic contaminants (Sligo Action Plan 2009). The purpose of this study was to locate the upstream source of Sligo Creek chlordane and compare passive monitoring using solid

polyoxymethylene strips and active monitoring using local *Corbicula* clams from the Potomac River (Phelps 1985).

#### Materials and Methods:

Chlordane monitoring in upper Sligo Creek began July 2010 by collecting Blacknose Dace minnows at site SCF (Fig. 1, Fig. 2) using a permitted square meter minnow net. The minnows were frozen, picked up by TestAmerica (Baltimore), and sent to the TestAmerica Laboratory of Burlington VT for pesticide analysis. *Corbicula* clams for the ABM translocation studies were collected on 7/5/10, 8/24/10, 9/10/10, and 10/3/10 from the shoreline sandy sediment at the Potomac River reference site of Fort Foote (FF) 5 km below the Anacostia confluence. A subsample of the first clam collection (7/5/10) received complete EPA Priority Pollutant analysis. The collected clams were kept cool and dry and placed in plastic-coated wire mesh cages (raccoon protection) on the stream bottoms at Sligo Creek sites within four hours. All ABM clam deployments were analyzed for 21 pesticides plus technical chlordane at two weeks unless otherwise specified, and had continuous temperature monitors (Tidbit) attached. Alpha and gamma chlordane are part of the EPA Priority Pollutant scan. Technical chlordane, which was analyzed separately, includes several additional chlordane compounds and is used by the US Food and Drug Administration (USFDA) for fish consumption advice.

The furthest downstream Sligo Creek site (SCF) was the sampling location for Blacknose Dace minnows and sediment (SSCF, Table 1, Fig. 1, Fig. 2)). ABM at SCF compared chlordane accumulation among small clams (13 – 18mm, SCFCS) and large clams (22 – 40mm, SCFCL) (Fig. 2, Table 1). The ABM/POM study at site SCF used four 1" x 4" polyoxymethylene (POM) strips wrapped in wire mesh with two placed per clam cage for two and four weeks (SCFC2, SCFC4, POM2a, POM2b, POM4a, POM4b). Dr. Upal Ghosh of the University of Maryland Baltimore Campus (UMBC) supplied the POM strips and analyzed them for alpha and gamma chlordane (Phelps 2010).

The uppermost possible Sligo Creek ABM was at the headwater site (SCH) located just below the junction of a large community stormwater drain and a smaller side drain (Fig. 1). The ABM sites in the upper Sligo Creek were in order going downstream: SCH, SC1, SC2, SCB (bridge) above Route 193, and SCH3 below Route 193, then site SCF (Fig. 2). Route 193 at Sligo Creek had large apartment buildings and a pond with a dam.

For ABM the tissues of all clams in a site (20-30) were combined as a single sample. For statistical purposes data below the detection limit was assigned a value of 0. In 2001 six subsamples of a reference clam sample (site FF) were analyzed for nine PAHs to determine analytical variability (Phelps 2002). The coefficient of variation (CV) was 9 – 18% and the relationship of standard deviation (SD) to mean was:  $SD = 0.175(\text{MEAN}) - 1.12$  ( $R^2 = 0.94$ ). This analytical variability was assumed for all contaminants and used to determine significant difference by t test.

## Results and Discussion:

The sediment sample collected at site SCF was sandy gravel (18% water) having 0.22% carbon. The sediment technical chlordane of 36 ug/Kg (dw) was 4X the Probable Effects Level of 8.87 ug/Kg for freshwater sediment (Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. 1999) and exceeded the NOAA SQUIRT table Upper Effects Threshold for freshwater sediment chlordane effects on biota (30 ug/Kg) (NOAA) (Table 1). SCF sediment chlordane normalized to organic carbon was 1600 ug/Kg C, similar to chlordane in Anacostia tidal sediments (NOAA 2002). This suggested Sligo Creek as a potential ongoing source of chlordane-contaminated sediment to the Anacostia tidal region. The chlordane in tidal Anacostia sediment was highest upstream and chlordane sources have not been identified in the tidal region (Wade et al. 1994). Another possible source of chlordane-contaminated tidal sediment could be the Riverdale East subtributary of the Northeast Branch with high chlordane but no fish (Phelps 2005, Phelps 2008).

Blacknose Dace minnows at site SCF had technical chlordane of 1500 ug/Kg, which is 5X the USFDA standard for fish consumption (300 ug/Kg) and statistically the same as four-week clam chlordane (1300 ug/Kg) (Table 1). A USGS 1992-1995 National Water-Quality Assessment survey found technical chlordane in native bivalves at freshwater sites averaged one-third of fish chlordane (Wong et al. 2000). Small and large clams deployed for two weeks had statistically similar concentrations of technical chlordane, averaging 1020 ug/Kg, which is 3.4X the USFDA standard for fish (Table 1).

Technical chlordane by ABM exceeded the USFDA standard for fish consumption at all sites except site SCH3 below the pond and dam at Route 193. Since clams at site SCF had higher chlordane levels than at upstream sites SCF may have had an additional source of chlordane (Fig. 2). SCF was located just below the entrance of a large drain from a nearby suburban area.

At Site SCB the first set of deployed clams on 9/17/10 was found dead after the two week deployment. The attached TidbiT showed the clams were not out of water. The second SCB deployment on 10/17/10 had 100% clam survival. Electrofishing on 10/28/2011 by the Maryland Department of the Environment (MDE) found many Blacknose Dace minnows at SCF but all sites above Route 193 (SCH, SCH1, SCH2, SCB) had only a few tolerant sunfish (Fig. 2). MDE will analyze those fish for chlordane. *Corbicula* clams are tolerant of high pollutants (Dougherty and Cherry 1988) and chlordane was significantly higher at SCF than all upstream sites, so high chlordane was probably not the cause of SCB clam death. The absence of fish and the one-time SCB clam death suggested an upstream cause of intermittent toxicity. The Friends of Sligo Creek website (<http://www.fosc.org/SWMap17.htm>) describes a large underground stormwater storage facility constructed under the Arcola Elementary School playground near site SCH. Underground water can become deoxygenated from organic matter and bacterial action (pers. information, Maryland Department of Natural Resources, MDDNR). Intermittent toxicity in Upper Sligo Creek could result from the slow release of anoxic stored water from the stormwater storage facility. The dam at Route 193 could block upstream migration and restoration of the Blacknose Dace minnow population.

Similar underground stormwater storage facilities are being proposed. Putting a small waterfall at the outlets could restore proper oxygen levels if necessary (MDDNR).

In this study both passive (POM) and active (ABM) monitoring showed a chlordane increase of 1.5X from two to four weeks deployment. The averaged chlordane by POM was 34% of clam ABM (Table 1). A similar ABM/POM study for PCBs in Lower Beaverdam Creek was carried out with Dr. Ghosh in 2009 (Phelps 2010). POM chlordane is reported in units per dry weight and ABM chlordane is traditionally reported in units of tissue wet weight (80% water). In the present chlordane study, if alpha and gamma chlordane were reported in dry weight units for both ABM and POM, POM would average 3.5X ABM chlordane levels. In the earlier ABM/POM study of PCBs in Lower Beaverdam Creek, total PCB levels by POM averaged 2X total ABM PCBs when measured by dry weight (Phelps 2010). This shows a difference among PCB and chlordane pollution measured by POM and ABM monitoring. Both PCBs and Chlordane are PBT contaminants with serious effects on downstream environments and higher organisms like birds. All of Sligo Creek is being seriously contaminated by its upstream chlordane sources. Monitoring by ABM is only the first start in addressing Sligo Creek toxic pollution but it does identify the major contaminants and possible sources. Further steps need to include developing a chlordane TMDL and possible sequestration measures.

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Table 1. Chemical and physical data at Upper Sligo Creek monitoring sites.

SITE	SLIGO CREEK LOCATION	DATE COLL.	CHLORDANE ng/Kg, gamma	alpha	gamma +alpha	technical	GPS northing	westing
SCH	Headwater	7/22/10	17	27	44	300	39.042721	77.039543
SCH1	Below SCH	10/17/10	46	72	118	710	39.042202	77.037674
SCH2	Below SCH1	10/17/10	20	39	59	370	39.041154	77.035698
SCB	Bridge	10/17/10	63	77	140	830	39.040127	77.034332
SCH3	Below bridge	10/17/10	10	19	29	150	39.042721	77.029850
SCFCS	*Small clams	9/7/10	110	58	168	940	39.024777	77.030157
SCFCL	*Large clams	9/7/10	140	77	217	1100	"	"
SCF2	*Clams 2 weeks	9/24/10	100	53	153	845	"	"
SCF4	*Clams 4 weeks	10/9/10	160	81	241	1300	"	"
SCF	*Fish	7/2/10	100	190	290	1500	"	"
POM2A	*POMa 2 weeks	9/24/10	25	20	45	(231)	"	"
POM2B	*POMB 2 weeks	9/24/10	36	25	61	(321)	"	"
POM4A	*POMa 4 weeks	10/9/10	46	34	80	(422)	"	"
POM4B	*POMB 4 weeks	10/9/10	47	36	83	(437)	"	"
SSCF	*Sediment	10/17/10	4	4	8	36	"	"
FF	Reference site	7/5/10	10	19	29	110	38.461694	77.014797

\*at site SCF

( ) estimated

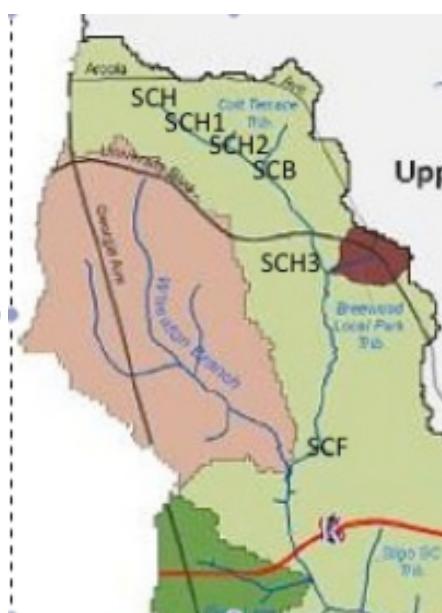
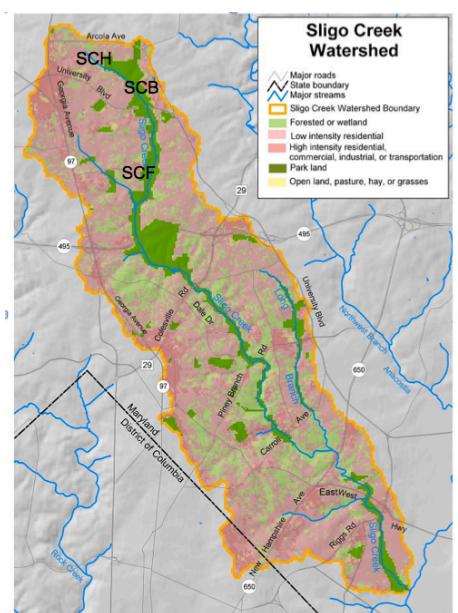


Figure 1. Sligo Creek watershed.

Figure 2. Upper Sligo Creek monitoring sites.

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