CONTAMINATION PROFILES OF PERSISTENT ORGANOCHLORINES AND POLYBROMINATED DIPHENYL ETHERS IN FISH FROM COASTAL WATERS OFF SAVANNAH, GA, USA

Sajwan KS[1], Nune S[2], Richardson J[3], Senthilkumar K[1] and Loganathan BG[2]

[1]Department of Natural Sciences and Mathematics, Savannah State University, 3219 College Street, Savannah, GA 31404, USA; [2]Department of Chemistry and Center for Reservoir Research, Murray State University, Murray, KY 42071-3346, USA; [3]Marine Sciences Program, Savannah State University, 3219 College Street, Savannah, GA 31404, USA.

Introduction

Persistent Organic Pollutants (POPs) such as polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) are known for their contamination in the global environment, bio-magnification in the food chain and long-term health effects in humans and wildlife[1,2]. Although organochlorine compounds were banned/severely restricted production and use in most of the developed countries, due their recalcitrant properties, these compounds continue to contaminate the environment and cause serious environmental and health problems. In addition, environmental contamination by emerging new pollutants such as polybrominated diphenyl ethers (PBDEs) is also of great concern. PBDEs have been used as chemical additives to reduce the flammability of domestic products including computer casings, carpet pads, to foam cushions in chairs and couches. PBDEs have been detected in air, soil and sediment, and in aquatic and terrestrial organisms including humans[3,4]. One of the major routes of human exposure to PCBs and other halogenated environmental pollutants is consumption of contaminated fish. The purpose of this study was to determine the levels of PCBs, chlorinated pesticides and PBDEs in fish collected from Atlantic coastal waters off Savannah (near Fort Pulaski), Georgia, USA.

Savannah River is ranked 7th among 50 highly contaminated rivers in USA receive 13,968,965 total pounds of direct toxic discharges to water[5]. Fish tend to bio-accumulate significant amounts of POPs and PBDEs. Besides, fish food is major transporters of toxic contaminants to humans and wildlife. In this study, we measured organochlorine/bromine compounds such as polychlorinated biphenyls (PCBs), DDT compounds [Dichloro 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane], chlordane compounds, cyclodienes, hexachlorobenzene (HCB), γ-hexachlorocyclohexane (γ-HCH), mirex and PBDEs in various fish species from 3 different regions along the coastal waters off Savannah, GA. The fish contamination levels were compared with Food and Drug Administrations (FDA) established values.

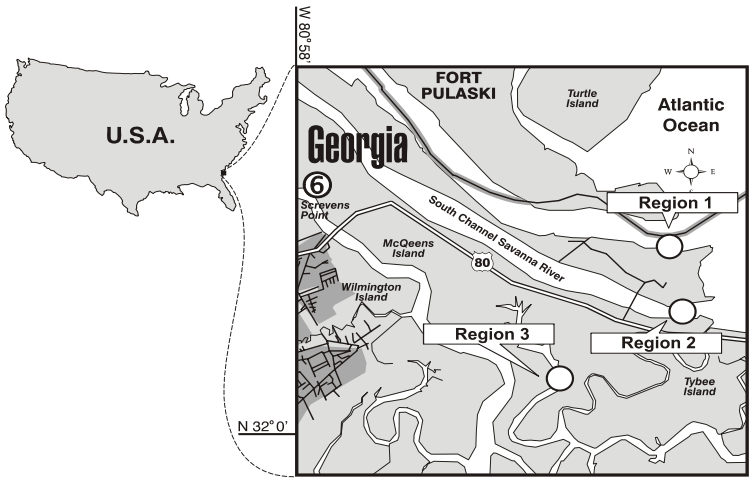

Figure 1. Map showing sampling locations

Materials and Methods

Details of sampling locations and samples are given in Figure 1 and Table 1. Three fish species from Savannah River Front (N32 01.95, W80 53.42) were collected on 20th and 26th October 2005. Four fish species from Lazaretto Creek N mouth (N32 01.22, W80 53.31) were collected on 20th and 26th October 2005 Six fish species from Oyster Creek (N32 00.52, W80 54.77) were collected on 20th October 2005. The fish were identified, measured , wrapped in aluminium foil and

transported to laboratory. The fish samples were stored at -20°C until analyzed.

PCB congeners, chlorinated pesticides and PBDEs were analyzed in fish tissues using approved procedures[6,7]. The freeze dried samples were subjected to Soxhlet extraction, volume reduction, fat analysis, fat removal from aliquot of extract by dry Florisil column and fractionated using silica gel column chromatography to remove interfering organic and polar species and to separate the PCBs from the PBDEs[7] and pesticides[6]. After clean-up, the sample extracts were injected in to Varian model CP-3380 gas chromatograph (GC) with Varian model CP-8410-auto injector equipped with 63Ni electron capture detector. Appropriate quality assurance and quality control analysis were performed. The concentration of analytes detected in the reagent blank was less than the method detection limit. The concentrations of PCBs and OCPs were ng/g lipid basis unless specified otherwise.

Results and Discussion

Savannah River Front

Table 1 shows tPCBs, chlorinated pesticides and PBDE concentrations in fish from Atlantic coastal waters off Savannah, GA. Among various contaminants, Total PCBs exhibited relatively higher concentrations than other analytes 63-496 ng/g fat wt.). PBDEs, showed comparatively greater concentrations than chlorinated pesticides. PBDE concentrations were ranged from 69-337 ng/g fat wt. (Table 1). Silver perch accumulated higher levels of contaminants than other fish species studied. Detection of 4,4'-DDT in fish tissues, indicate recent contamination. Of 12 PBDEs analyzed, 4-7 PBDE congeners were detected in this region in which total PBDEs were slightly less than PCBs but significantly greater than pesticides. PBDE-30 was predominant congener (except anchovy in which PBDE-99 was prevalent) followed by PBDE-47, PBDE-99 in two fish species.

Table 1. Concentrations of PCBs, PBDEs and organochlorines pesticides (ng/g fat wt.) in fish from Savannah River Front.

Common Name # of Individuals *Genus and Sp.*	Flounder (n=2) *Paralichthys lethostigma*	Flounder (n=1) *Paralichthys lethostigma*	Anchovy (n=30) *Anchoa mitchilli*	Silver Perch (n=2) *Cynoscion nothus*
Total PCBs	63	111	134	496
Total PBDEs	71	108	69	337
HCB	<0.17	<0.22	<0.31	0.68
γ-HCH	0.49	0.38	1.4	1.3
Total Cyclodines	5.2	7.7	2.9	25
Total Chlordanes	12	16	5.7	34
Total DDTs	21	23	34	153
Mirex	3.1	<0.10	<0.10	<0.10
Total OCPs	42	47	44	214

Table 2. Concentrations of PCBs, PBDEs and organochlorine pesticides (ng/g fat wt.) in fish from Savannah River Lazaretto Creek N Mouth.

Common Name # of Individuals *Genus and Sp.*	Anchovy (n=26) *Anchoa mitchilli*	Flounder (n=1) *Paralichthys lethostigma*	Flounder (n=1) *Paralichthys lethostigma*	Rock Seabass (n=1) *Centopristis philadelphica*	Rock Seabass (n=1) *Centopristis philadelphica*	Silver Perch (n=1) *Cynoscion nothus*
Total PCBs	35	107	36	12	72	154
Total PBDEs	67	74	69	21	10	26
HCB	0.20	<0.10	0.48	0.24	<0.10	0.28
γ-HCH	0.18	0.20	0.17	0.15	0.17	0.26
Total Cyclodines	<0.10	4.4	3.3	4.4	5.1	<0.10
Total Chlordanes	4.3	7.0	3.8	6.2	6.1	4.5
Total DDTs	11	8.9	7.3	8.1	11	16
Mirex	6.9	4.6	<0.10	<0.10	<0.10	<0.10
Total OCPs	23	25	15	19	22	21

Lazaretto Creek N mouth

Concentrations of tPCBs, tPBDEs and chlorinated pesticides in fish from Lazaretto Creek North mouth is shown in Table 2. As seen in Savannah River Front fish tissues, tPCBs were major contaminants followed by PBDEs, and other pesticides in Lazaretto Creek North mouth. Several of the chlorinated pesticides were not detected/or barely detected (Table 2). Silver perch and a Flounder had greater PCBs. Where as, concentrations of DDTs were in the following order: silver perch < rock sea bass < anchovy=flounder. Concentrations of chlordanes, HCB, γ-HCH, cyclodines (except anchovy) were similar in all fish species. Similar to Savannah River Front fish, two to eight congeners of PBDEs were detected in this region. Particularly, PBDE-30 was predominant and found in higher concentrations than other PBDEs. PBDE-47 was predominant in one rock sea bass and PBDE-99 was prevalent in anchovy pooled sample, which is consistent to the anchovies pooled from Savannah River Front. PBDEs were comparatively lower concentrations in fish from Lazaretto Creek N mouth than in fish from Savannah River Front.

Table 3. Concentrations of PCBs, PBDEs and organochlorine pesticides (ng/g fat wt.) in fish from Savannah River Oyster Creek.

Common Name # of Individuals	Rock Seabass (n=1)	Silver Perch (n=9)	Spot (n=1)	Spade fish (2)	Flounder (n=6)
Genus and Sp.	*Centropristis philadelphica*	*Cynoscion nothus*	*Leiostomus xanthurus*	*Chaetodipterus faber*	*Paralichthys lethostigma*
Total PCBs	201	42	71	77	109
Total PBDEs	61	17	17	66	39
HCB	0.28	<0.11	<0.10	0.22	<0.17
γ-HCH	<0.10	0.23	0.28	0.24	<0.10
Total Cyclodines	<0.10	3.9	5.8	35	0.93
Total Chlordanes	5.3	8.5	8.2	4.7	4.0
Total DDTs	7.3	10	19	51	2.7
Mirex	<0.10	<0.10	<0.10	8.6	<0.10
Total OCPs	13	23	33	100	7.6

Oyster Creek

POPs and PBDE concentrations in fish from Savannah River oyster creek is presented in Table 3. Similar to Savannah River Front and Lazeretto Creek, in oyster creek fish samples contained greater concentrations of total PCBs followed by PBDEs, DDT and its metabolites, chlordanes and cyclodines, while, HCB, γ-HCH and mirex were showed either barely detected or less than detection limit (Table 3). Greater PCBs concentrations were noticed in rock sea bass while lowest concentration was noticed in silver perch. Spot, spade fish and flounder showed similar PCB concentrations. Contaminations of organochlorine pesticides were similar to Savannah River Front. Among PBDEs, PBDE-30 was predominant congener in Oyster Creek followed by PBDE-99 and PBDE-47. In all, 4-6 congeners were detected in this region and the concentrations were similar to Lazaretto Creek N mouth but lower than Savannah River Front.

Occurrence of 4,4'-DDT in fish tissues from Atlantic coastal waters off Savannah indicate current contamination. Since, DDT is no longer produced and used in the United States, source of 4,4'-DDT to the fish in this region is not known. Long-range atmospheric transportation from other countries that still use DDT may be possible source of contamination. cis-Chlordane and dieldrin were prevalent contaminants among chlordanes and cyclodienes, respectively. Comparatively lower concentrations of trans-nonachlor than cis-chlordane, heptachlor and heptachlor epoxide indicate non-point source contamination. Occurrence of mirex in anchovies, flounder and spade fish reflects presence of mirex in Fort Pulaski waters at low levels. Persistent

organochlorine compounds contamination levels in fish from Atlantic coastal waters off Savannah, GA are comparable or less than the contamination levels reported for fish and other biota from coastal waters off Florida and Gulf of Mexico[8].

Among the various PBDE congeners measured, PBDE-30, PBDE-47, PBDE-66, PBDE-99, PBDE-153 were frequently detected in the samples. In general, the organohalogen concentrations in fish were in the following order: tPCB = tPBDEs > chlorinated pesticides. To our knowledge, this is the first report on the PBDE concentrations in fish from Atlantic coaster waters near Fort Pulaski, GA. The levels of PCBs and chlorinated pesticides in fish from Atlantic coastal waters near Fort Pulaski were below the Food and Drug Administrations (FDA) established limits for human consumption[8].

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