Estrogenicity of Channel Catfish (Ictalurus punctatus) Tissue is Associated with High Densities of Combined Sewer Overflows in Pittsburgh, PA; Implications for Human Population Exposure to Xenoestrogens from Drinking Water in the Greater Pittsburgh Metropolitan Area – Poster# H10

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Background

There is overwhelming evidence that effluents from sewage treatment plants and combined sewer overflows (CSO's) exhibit strong human and animal in vitro and in vivo wildlife estrogenic activity. A wide range of estrogenic agents is contained in municipal wastewater including pharmaceutical estrogens, phthalates, bisphenol-A, pesticides and detergent breakdown products like nonyl-phenol. Some xenoestrogens bioaccumulate in aquatic systems because of their high lipid solubility. The Three Rivers area of Pittsburgh has more CSO release points (over 200) than any other city in the United States, which release untreated waste directly into receiving water during wet weather events. Rainfall amounts of about 1/10 inch can trigger opening of sewer outfall gates.

Venture Outdoors Angler with Catfish Catch at Point State Park

Objectives

1. To determine if the xenoestrogen concentrations as measured by MCF-7 proliferative indexes in catfish vary by proximity to dense concentrations of combined sewer overflows (CSO's).

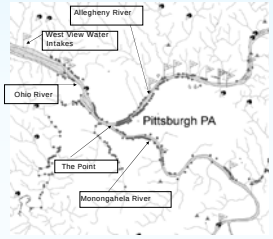
2. To use catfish as sentinels to help identify the sources of xenoestrogen pollution.

3. To help gauge exposure and thus risk to human population groups from xenoestrogens, which are bioaccumulated in catfish and present in intake water supplied to homes through the water authorities of the Greater Pittsburgh Metropolitan Area.

4.To involve semi-subsistence and recreational anglers in a Community Based Participatory Environmental Research Project.

5. To demonstrate to policymakers the biological effects of failure to update Pittsburgh's antiquated sewer system.

Map 1 -grey dots denote CSO points identified by Three Rivers Wet Weather, flags indicate municipal water intakes. Notice the density of CSO's in the Three Rivers area surrounding Pittsburgh. West View Water (WVW) intakes are located downstream of these CSO points on the Ohio River below the ALCOSAN treatment plant effluent release point. WVW serves a large portion of the northern Allegheny County area.



Methods

We sought to determine if there are locational differences in estrogenicity index of channel catfish, as determined by the MCF-7 cell proliferation assay, caught in areas significantly impaired by CSO's and industrial effluent compared to those from up-river areas on the Allegheny River that are less impacted. The MCF-7 human breast cancer cell line is alpha estrogen receptor positive and is exquisitely sensitive to estrogen and estrogen mimicking chemicals. The presented estrogenicity index is based on the ratio of the MCF-7 cell proliferation achieved from application of fish extract to the proliferative response achieved from the addition of a 1 nM solution of estradiol (E2). All catfish were caught using rod and reel by local anglers as scientists catch smaller fish on average leading to underestimates of risk.

All CSO and sanitary sewer outflows (SSO's) in the Three Rivers Area were identified by latitude and longitude. The density of CSO/SSO outfalls was greatest at Point State Park and at the Braddock Dam on the Monongahela River. CSO/SSO outfall density significantly decreased near the Highland Park Dam in Sharpsburg and near Kittanning PA, both on the Allegheny River. The mean estrogenicity index of fishes from areas of dense- high CSO/SSO (n=10) were compared with those from low CSO/SSO density areas (n=9) using ANOVA on SPSS Version 12.0.

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Results

Figure 1 presents the mean estrogenicity index (y axis) for each serial dilution of catfish extract (x axis) by river location. 1-Monongahela River, Braddock Dam, 2-Allegheny River, Highland Park, 3-Allegheny River, Kittanning, 4- Storebought Fish, 5-Catfish from Point State Park

Serial dilutions shown are 1/100, 1/200, 1/500, 1/1000, 1/1500, 1/2000, 1/3000 and 1/4000 of fish extracts, presented from most to least concentrated. Note the high mean estrogenicity index for the 1/100 dilution points and large area under the dilution curves for the Point (6) and the Monongahela River (1). River (2) and (3), the Allegheny at Highland Park and Kittanning, respectively have similar mean 1/100 estrogenicity indexes and dilution curves, which are well below rivers (1) and (6) . The 1/100 mean estrogenicity index for storebought fish and area under the dilution curve (4) is lower than those for the Allegheny River sites

Figure 1, Estrogenicity Index by River

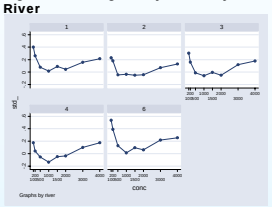
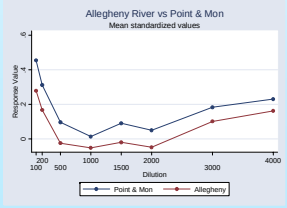


Figure 2 presents the mean estrogenicity index for fish from the most contaminated CSO sites (Point State Park and Monongahela, Braddock) versus the mean estrogenicity index for catfish from areas on the Allegheny (Highland Park, Kittanning) with less CSO density. The mean estrogenicity index for all fish extract dilutions in the high CSO areas are above those from the low density CSO locations.

Figure 2, Mean Normalized (to Estradiol Response) Estrogenicity Index, Allegheny River Sites versus the Point and Monongahela River



Conclusions

ANOVA revealed that catfish caught at locations of dense concentrations of CSO outfalls had significantly higher estrogenicity indexes than catfish from areas of less dense CSO effluents. This relationship was significant at p=.02, .03, .01, .04, .01, <.01, .04 and .06 for the 1/100, 1/200, 1/500, 1/1000, 1/1500, 1/3000, and 1/4000 dilutions, respectively.

We conclude that fish caught in the densely concentrated areas of CSO's are exposed to and have bioaccumulated more xenoestrogens than fish caught in less CSO impacted areas. While the specific estrogenic compounds that produced this effect were not isolated from fish tissue, the literature supports that a wide range of household and personal care products, pharmaceuticals, and lawn and garden pesticides with estrogenic potential are being emitted from these CSO's.

Naturalistic wildlife and holistic ecosystem effects studies provide valuable risk information concerning cumulative estrogenicity at the level of a system or population. An important aspect of the total risk to humans and the environment from ingestion of xenoestrogens is the profusion of substances with estrogenic activity that are being introduced into water through municipal (household) sources. The EPA must incorporate appropriate methodologies to evaluate total estrogenic risk from environmental mixtures of commonly found xenoestrogens. E-screen evaluation of the channel catfish is proposed as one model for further discussion and development.

Public Health Implications

1. In a Danish study, exposure to xenoestrogens, through the food supply and water intake has been associated with extremely high rates of Testicular Dysgenesis Syndrome, including testicular carcinoma in situ.
2. River water, from CSO impacted areas, is the primary source of drinking water for many residents of the Greater Pittsburgh area. Water treatment technologies aren't adequate for xenoestrogen removal thus exposing large, susceptible population groups to xenoestrogens.
3. Semi-subsistence anglers and their families, who may consume up to 4 meals per week of river caught fish are potentially at risk for development of estrogen induced disorders.

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