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Chromium Accumulation in Three Species of Central Florida Centrarchids

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Stormwater ponds are required in Central Florida when land is developed to treat the resulting stormwater. The St. Johns River Water Management District, the agency that regulates stormwater discharges in Central Florida, frequently approves plans that create habitat for fish and wildlife by planting desirable wetland and aquatic vegetation in the littoral zones of stormwater ponds to compensate for the loss of wetlands. The various species of fish that inhabit stormwater ponds serve as a food source to wildlife, especially wading birds. The objective of this study was to determine if fish that live in stormwater treatment ponds in Orlando, Florida contained significant concentrations of chromium (Campbell 1993).

In order to determine if there were differences in chromium concentrations in fish with different foraging strategies, three species of sunfish (Centrarchidae) with substantially different foraging strategies were selected for this study: largemouth bass (Micropterus salmoides), a predator; redear sunfish (Lepomis microlophus), a bottom feeder; and bluegill sunfish (Lepomis macrochirus), an omnivore (Tomelleri and Eberle 1990).

Many researchers have shown that large quantities of chromium are found in urban runoff (Owe et al. 1982). Chromium sources are largely associated with the operation of motor vehicles (Harper 1985). Several investigators have determined that chromium from urban runoff concentrates in the sediment of stormwater ponds (Harper 1985; Yousef et al. 1991). Sediments represent the most concentrated physical pool of metals in aquatic environments, and they are ingested by many types of aquatic organisms (Luoma 1983). Most fish are capable of accumulating heavy metals from their diet and from water through their gills (Patrick and Loutit 1978).

MATERIALS AND METHODS

A preliminary study was done to determine the fish species composition of several stormwater ponds. Stormwater ponds selected for the study met the following criteria: (1) the pond was located in the Orlando area; (2) the project associated with the pond was a shopping center, an apartment complex, or a road; (3) the project was built between 1983 and 1988; and (4) wading birds had been observed feeding. Reference sites selected were ponds or lakes located in the Greater Orlando area that did not receive any urban or road runoff. The selected stormwater ponds and reference sites are shown and described in detail in Campbell (1994). Fish were collected in December 1991, January 1992, and March 1992 using seines, a gill net, and an electrofishing boat. Because all three selected sunfish species did not occur in all stormwater ponds, seven stormwater ponds were required for the study (Campbell 1994).

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Fifteen bass were collected from three stormwater ponds, five fish from each pond. Five redear sunfish were collected from each of three stormwater ponds. Five bluegill were collected from each of the three stormwater ponds which contained bluegill. Four reference sites were required for the study in order that each species could be collected from three different reference sites. Five bass, redear, and bluegill were collected from each of three reference sites. Each fish was measured (cm), tagged, and placed in a sterile plastic bag. The fish were placed on ice and later frozen until they were taken to the laboratory for analysis.

A composite sediment sample was collected from each of the seven stormwater ponds and four reference sites on, or near, the date that the fish were collected. Each sample was placed in a sterile plastic bag and kept on ice until it was taken to the laboratory for analysis.

The fish and the composite sediment samples were taken to Flowers Chemical Laboratories, Inc. (481 Newburyport, Altamonte Springs, Florida) for chromium analysis. At the laboratory, each whole fish was weighed (g) and pureed in a Waring blender. A subsample (0.2 to 0.5 g) of each puree was used for the microwave digestion procedure and digested according to EPA Method 3051 (USEPA 1986). Each fish was analyzed for chromium (Cr) using the Atomic Absorption Direct Aspiration Method, EPA Method 7190 (USEPA 1986). The minimum level of detection was 0.002 mg/kg wet weight. A representative 0.5 g of each sediment sample was digested and analyzed as described above. All concentrations were determined on a wet weight basis.

Analysis of Variance (ANOVA) was used to determine differences in chromium concentrations between fish (and sediment) from stormwater ponds and reference sites (SAS Institute Inc 1985). The Bonferroni Multiple Comparisons Procedure was used to compare the mean concentrations. This procedure also was used to compare fish size. The overall level of significance was set at $p<0.005$ because multiple comparisons were done. A correlation analysis was done to determine any correlation between the length and weight of the fish and the chromium concentration.

RESULTS AND DISCUSSION

The mean lengths and weights of the fish are listed in Table 1. The bass and redear collected from stormwater ponds and reference sites were not significantly different ($p>0.005$) in size. However, because reference sites did not contain bluegill that were as small as those from stormwater ponds, there was a significant difference ($p<0.005$) in size of bluegill collected from stormwater ponds and reference sites.

Largemouth bass from reference sites contained a significantly higher ($p<0.005$) chromium concentration than those from stormwater ponds (Table 2, Fig. 1). Largemouth bass from the reference sites contained the highest mean concentration of any fish sampled. The mean chromium concentration in redear sunfish was higher in fish collected from the reference sites than those from stormwater ponds; however, the difference was not statistically significant ($p>0.005$) (Table 2, Fig. 1). The concentrations in bluegill sunfish from stormwater ponds and reference sites were similar and not statistically different ($p>0.005$) (Table 2, Fig. 1). The chromium concentration in composite sediment samples from the reference sites was two times higher than those from stormwater ponds; however, the concentrations were not significantly different ($p>0.005$) (Table 2). No significant correlation between the chromium concentration and the length and the weight of the three species of fish was observed (Table 3).

Chromium sources (automobile engine wear and brake linings) did not explain why bass from reference sites contained a significantly higher concentration than those from stormwater ponds. Significantly higher concentrations probably also would have been observed in redear

Table 1. The mean length (cm) and weight (g) of fish collected, December 1991-March 1992, Orlando, Florida.

Species	Mean Length $\pm$ SD	Range	Mean Weight $\pm$ SD	Range
Stormwater Ponds				
Largemouth bass	14.6 $\pm$ 6.6	7.8, 25.8	55.6 $\pm$ 64.2	3.8, 193.2
Redear sunfish	11.5 $\pm$ 2.7	7.4, 17.0	33.5 $\pm$ 29.1	5.9, 110.0
Bluegill sunfish	9.3 $\pm$ 2.4	5.6, 12.6	14.9 $\pm$ 11.2	3.6, 39.5
Reference Sites				
Largemouth bass	20.4 $\pm$ 6.6	11.5, 30.3	116.7 $\pm$ 109.4	12.5, 323.8
Redear sunfish	12.1 $\pm$ 1.9	9.1, 15.0	27.8 $\pm$ 13.4	8.9, 49.1
Bluegill sunfish	14.6 $\pm$ 3.3	9.2, 20.6	57.8 $\pm$ 41.3	14.7, 154.7

Table 2. Chromium concentrations (mg/kg wet wt.) of fish and composite sediment collected, December 1991-March 1992, Orlando, Florida.

Species	N	Mean Cr Concentration	S.D.	Range
Stormwater Ponds				
Largemouth bass	15	0.108	0.299	<0.005, 0.444
Redear sunfish	15	0.205	0.559	<0.005, 2.00
Bluegill sunfish	15	0.532	0.124	0.367, 0.796
Composite sediment	7	2.180	0.843	0.744, 3.08
Reference Sites				
Largemouth bass	15	0.658	0.232	0.393, 1.18
Redear sunfish	15	0.437	0.215	0.072, 0.885
Bluegill sunfish	15	0.489	0.105	0.371, 0.787
Composite sediment	4	4.270	5.820	0.551, 12.90

Table 3. Correlation coefficients of chromium concentration vs. length and weight of fish. All correlations are non-significant ($p>0.05$).

Species	Length	Weight
Largemouth bass	-0.2292	-0.2322
Redear sunfish	0.4683	0.3745
Bluegill sunfish	-0.3172	-0.3073

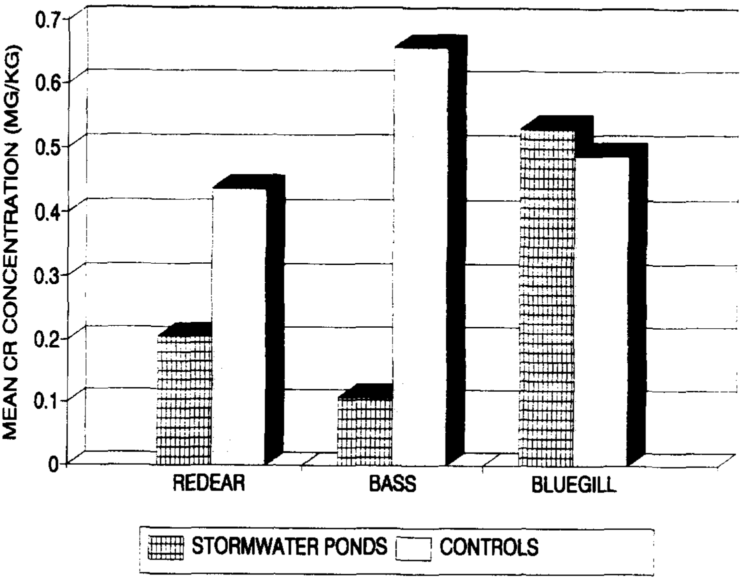

Figure 1. The mean chromium concentrations of redear sunfish, largemouth bass, and bluegill sunfish collected from stormwater ponds and control (reference) sites, December 1991-March 1992, Orlando, Florida.

and sediment from reference sites if sample sizes had been larger. It was expected that fish collected from stormwater ponds would contain higher chromium concentrations than fish from reference sites because of the continuous input of stormwater containing chromium. Reference sites were expected to contain fish and sediment that contained very low chromium concentrations (as compared to stormwater ponds). A much more detailed study is needed to determine the source of chromium found in the reference sites. Atmospheric deposition of chromium from a nearby coal-fueled power plant should be investigated in detail to determine if it was the cause of the elevated chromium levels in fish and sediment from the reference sites.

The chromium concentrations of the fish in this study were within the range of values of fish collected from other contaminated aquatic systems (Mathis and Cummings 1973; Tong et al. 1974; Giesy and Wiener 1977; Elwood et al. 1980; Wiener et al. 1982).

All available evidence suggests that chromium is not biomagnified (Nriagu and Nieboer 1988). However, the results of this study suggest that biomagnification could be occurring as the bass from the reference sites, which are at the top of the fish food chain, contained the highest chromium concentration of the fish collected. A much more detailed study is needed to determine if biomagnification of chromium is indeed occurring.

There is no consistent relationship reported between chromium concentration and fish size. Elwood et al. (1980) and Seenayya and Prahalad (1987) reported a negative correlation between the metal concentration and fish weight. In a study by Tong et al. (1974), chromium content increased with age in lake trout. Correlations between the whole body concentration and the fish total length were non-significant in a study done by Giesy and Wiener (1977) which were similar to the results obtained in this study.

Bass that live in clean, natural environments in Central Florida were found to contain a significant amount of chromium, which was not the expected result. The effect on the wading birds and other wildlife that are feeding on fish containing chromium is unknown and was beyond the scope of this study; however, the fish may represent a potentially contaminated food source for both wildlife and humans. A more detailed investigation should be undertaken to determine if a problem exists. At the present time, the focus of most of the effort regarding heavy metal pollution in Florida is on mercury, but other metals, such as chromium, should not be ignored.

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