Initial Assessment of Trace Element Exposure in Insectivorous Birds Nesting Near the Kingston Ash Spill

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INTRODUCTION

On December 22, 2008, the Tennessee Valley Authority (TVA) suffered a retaining wall failure at the Kingston Fossil Plant in Roane County, Tennessee. In April 2009, TVA initiated an investigation to examine potential impacts of the spill to insectivorous birds in the vicinity. Colonies of tree swallows (*Tachycineta bicolor*) were established near the ash spill to determine whether trace elements were being transferred from the ash into the surrounding terrestrial communities. Results from these colonies were compared to previously established tree swallow colonies on other TVA properties. The tree swallow investigation will serve as a foundation for upcoming work that will examine potential bioaccumulation of trace elements to avian receptors and their prey. Ultimately this and other studies will assess potential impacts and provide data to quantify impacts for future damage assessments.

OBJECTIVES

The goal of the study was to detect the potential transfer of trace elements from the ash into the surrounding terrestrial communities and establish a baseline for future comparisons.

Objective 1: Examine current levels of trace elements found in tree swallow eggs. These trace element profiles are important because several trace elements associated with coal ash are known to maternally transfer, subsequently causing reduced hatching success and increased incidence of developmental malformations.

Objective 2: Examine current levels of trace elements in tree swallow nestlings. Trace element concentrations in late-stage nestlings will primarily be indicative of prey collected by adults from the area near the nest.

METHODS

Colonies of tree swallows were established at three sites at the ash spill and two reference sites >11 miles from the spill. Seventy-six nests were monitored (30 at the spill, 46 at reference sites). From nests that were not predated, a single egg and a nestling (>day 14 old) were collected and tested for a suite of metals.

Objective 1: A single egg was removed from each nest. One duplicate was taken from one nest to test for analytical variation. Eggs were measured and frozen whole (≤ -20 °C). Eggs were shipped to Pace Analytical Services, Inc., where the contents were removed and tested for trace elements. All results are reported in dry weight.

Objective 2: A single nestling was removed from each nest. One duplicate nestling was also taken. Nestlings were euthanized by using CO_2 and/or cervical dislocation.

Weight of nestling, length of femur, and length of third primary were recorded. Nestlings were frozen whole and sent to Pace Analytical Services, Inc. All specimens were analyzed whole and all results are reported in dry weight.

Elements tested include Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Calcium (Ca), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Magnesium (Mg), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Potassium (K), Selenium (Se), Silver (Ag), Sodium (Na), Strontium (Sr), Thallium (Tl), Vanadium (V), and Zinc (Zn).

Figure 1. Study site and trapping localities at Kingston Fossil Plant, Roan County, Tennessee.

TVA biologists examining condition of tree swallow nestlings at Melton Hill Dam, Loudon County, Tennessee.

TVA and USFWS biologists removing a black rat snake (*Elaphe obsoleta obsoleta*) from a tree swallow nest box at Ft. Loudoun Dam, Loudon County, Tennessee.

RESULTS

Eggs

- Clutch initiation dates ranged from 30 April to 21 June 2009. Clutch sizes ranged from 2-7 eggs. Sixty-three eggs were collected and analyzed. For eleven elements, concentrations in all eggs from both sites were below detection (Al, Sb, As, Be, B, Cd, Co, Mo, Ag, Tl, and V.
- As and Cd concentrations in eggs were below detection (mean detection <0.41 ± 0.03 µg/g) in all eggs from all sites.
- Pb was detectable (0.44 µg/g) in 1 of 63 eggs (mean detection limit <0.41 ± 0.03 µg/g).
- Hg was detectable in 15 of 37 eggs (mean detection limit = 0.08 ± 0.01 µg/g) from the areas near the spill, but the average Hg concentration of these 15 eggs was low (0.12 ± 0.02 µg/g). In comparison, Hg was detectable in 4 of 26 eggs from the reference sites, averaging 0.09 ± 0.03 µg/g in these four individuals (Fig. 2).
- Se was quantifiable in all but two eggs (one near the spill and one from a reference site). Overall, Se concentrations in eggs from Kingston (2.94 ± 0.39 µg/g) and from reference sites (2.10 ± 0.25 µg/g) were similar. However, eggs collected from two nests nearest the ash spill were notable outliers (10.9 and 11.0 µg/g), both exceeding concentrations known to be harmful to some sensitive bird species.
- Currently, Sr has only been measured in a subset of eggs from both sites. Sr concentrations in eggs from the impacted sites were quite variable, but average concentrations were twice as high as those from the reference sites (Kingston = 6.05 ± 1.9; Reference sites = 2.96 ± 0.7 µg/g).

Nestlings

- Nestlings were first observed in boxes on 28 May. As some young were partially developed, earliest hatching date is estimated to be mid-May. Predation from snakes was common at established colonies.
- Forty-seven nestlings were collected and analyzed. For nine elements, concentrations in all nestlings from both sites were below detection (Al, Sb, Be, B, Cd, Mo, Ag, Tl, and V).
- Cd concentrations in nestlings were below detection (mean detection <0.29 ± 0.01 µg/g) in all nestlings from all sites.
- Pb and As concentrations in nestlings were below detection (mean detection <0.29 ± 0.01 µg/g) in all but one nestling each (0.12 and 0.25 µg/g; respectively).
- Hg was detectable in 31 of 35 nestlings (mean detection limit = 0.06 ± 0.01 µg/g) from the areas near the spill, but the average Hg concentration of these 31 nestlings was low (0.09 ± 0.004 µg/g). In comparison, Hg was detectable in 3 of 12 nestlings from the reference sites, averaging 0.06 ± 0.001 µg/g dry mass in these three individuals.
- Contrary to our predictions, Se concentrations in nestlings from Kingston (3.33 ± 0.11 µg/g) were slightly lower than those from the reference sites (5.44 ± 0.68 µg/g). The highest nestling concentrations were found in four nestlings from the reference site (range 7.4 – 9.0 µg/g). No nestlings from sites near the spill exceeded 4.8 µg/g (Fig. 3).
- Consistent with the site differences observed in eggs, Sr concentrations in nestlings from the impacted sites were twice as high as those from the reference sites (Kingston = 13.71 ± 1.8; Reference sites = 6.78 ± 1.2 µg/g). These Sr concentrations in nestlings were twice as high as those found in egg contents at both sites (Fig. 4).

Figure 2. Comparison of Mercury values observed in tree swallows at Kingston.

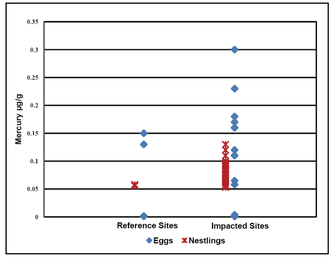


Figure 3. Comparison of Selenium values observed in tree swallows at Kingston.

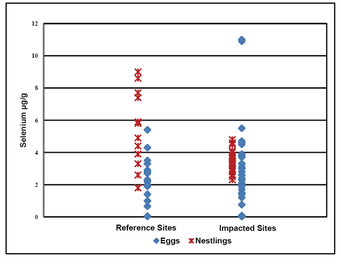
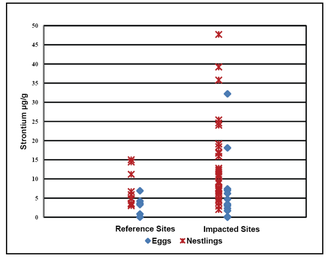


Figure 4. Comparison of Strontium values observed in tree swallows at Kingston.



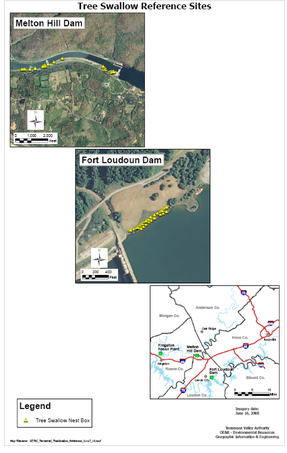


Figure 5. Trapping localities at reference sites and overview map.

DISCUSSION

Based on the initial sampling efforts, tree swallows do not yet appear to be experiencing widespread exposure to trace elements derived from coal ash. Most trace element concentrations in eggs and nestlings were low in both the impacted and reference sites. The two notable exceptions were Se and Sr concentrations in some individuals.

Two eggs collected from nests nearest the spill had Se concentrations exceeding 10 µg/g, but nestlings collected from the same nests had low whole body concentrations of Se (3.4, 4.6 µg/g). The fact that only two eggs and no nestlings had elevated Se at the Kingston site suggests that Se concentrations in emerging insects at the site may have been low in Spring/Summer 2009. This finding is important for other terrestrial consumers that also rely heavily on emerging aquatic insects (e.g., bats, spiders, and some herpetofauna).

Sr concentrations were twice as high in egg contents and nestlings from the Kingston site compared to the reference sites. Although it is unlikely that these Sr concentrations are of toxicological concern (Mora, 2003), this finding suggests that Sr is entering the aquatic food web and being transferred to terrestrial insectivores.

Future large-scale studies are currently being planned that will determine whether trace elements from the spill become more bioavailable over time, and whether tree swallows near the Kingston spill experience any adverse effects on reproduction, early development, and physiological processes (Brasso and Cristol, 2008; Wada et al., 2009).

REFERENCES

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RELATED STUDIES

TVA is examining emerging forms of benthic invertebrates to test for potential transfer of trace elements to the terrestrial wildlife communities. The annual summer emergence of burrowing mayflies may provide a potential route for the transfer of metals to terrestrial insectivores.

Burrowing mayflies on vegetation along riparian zone.

Burrowing mayflies emerging from the Tennessee River.

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