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# Biomonitoring in Poultry Raised on Mercury-Contaminated Floodplain Soils

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## INTRODUCTION

Mercury (Hg) was used in the manufacturing process at a textile plant in Waynesboro, Virginia between 1929 and 1950. In the course of the manufacturing process, Hg was released and subsequently migrated and accumulated in depositional areas along the South River (SR) and floodplain. Some floodplain residents keep poultry for consumption of eggs and meat. A Hg biomonitoring study was implemented in 2014 to address the potential for bioaccumulation and exposure to Hg through the ingestion of poultry raised on the floodplain. The purpose of the study was to assess the potential risk to human health associated with small-scale poultry operations located on the floodplain. Hg concentrations were quantified in eggs, muscle, liver, gizzard, feathers, and blood in three breeds of poultry raised in a contaminated portion of the SR floodplain and from uncontaminated control and reference areas / sources. Data from edible tissues were incorporated into standard ingestion exposure equations to estimate the potential human exposures that could result if similarly reared chickens were consumed as a source of food. Regression analysis was used to evaluate non-lethal monitoring methods. The investigation approach and relevant findings are presented.

## OBJECTIVES

Two study objectives:

1. Evaluate potential human exposure to Hg from eating poultry (chickens) and eggs raised in a contaminated portion of the SR floodplain and from unimpacted background locations within the Shenandoah Valley
2. Determine whether blood and / or feather data can be used to:
   a. Provide a non-invasive form of biomonitoring for Hg in poultry
   b. Demonstrate that Hg is eliminated from the birds via feathers

## APPROACH

### Experimental Design

- Three study sites (Figure 1)
  - SR contaminated floodplain
  - SR control
  - Reference
    - Local farm (Swoope, VA)
    - Grocery stores (2)
- 3 breeds (Figure 2)
- 5 month study period
- Samples collected monthly

*Figure 1. Study Sites, Augusta Forestry Center, Crimora, Virginia*

*SR Contaminated Floodplain*

*SR Control*

## APPROACH *(continued)*

### Hg Analysis

- Eggs
- Muscle (meat)
- Liver
- Feathers
- Blood
- Gizzard

### Data Analysis

- Calculated hazard quotients (HQs)
- Quantified allowable number of meals
- Regression analysis used to evaluate relationship between Hg levels in tissue

*Figure 2: Study Breeds*

*Barred Rock (BR), Red Star (RS), White Leghorn (WL)*

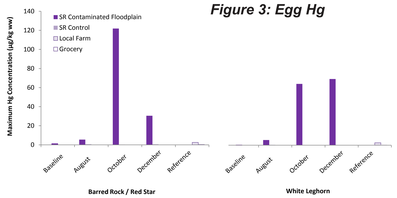
## RESULTS

### Hg in Edible Tissue

**Eggs**

Maximum Hg concentrations in eggs from SR contaminated floodplain higher than SR control and reference (Figure 3)

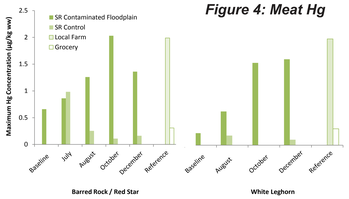
*Figure 3: Egg Hg*




**Meat**

Maximum Hg concentrations generally comparable between SR contaminated floodplain and local reference, higher than control (Figure 4)

*Figure 4: Meat Hg*




### Hazard Quotients

- Eggs / meat: HQs<1
- Gizzard: Barred rock / red star HQ<1
  White leghorn HQ=2
- Liver: Barred rock / red star HQ=3.0
  White leghorn HQ=6.7

### Allowable Meals (Per Month)[1] (Table 1)

Eggs: 183 eggs

Meat: 3,173 servings[2]

Gizzard: 43 servings

Liver: 15 servings

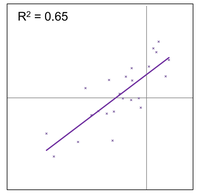
## RESULTS *(continued)*

*Table 1. Allowable Number of Meals Per Month[2]*

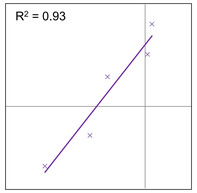
| Study Area | Eggs / Month | Meat Servings / Month | Gizzard Servings / Month | Liver Servings / Month |
|---|---|---|---|---|
| Grocery - Reference | 47,239 | 20,938 | 26,796 | 16,106 |
| Local Farm - Reference | 5,180 | 3,240 | -- | 1,083 |
| BR/RS - SR Contaminated Floodplain | 216 | 3,173 | 190 | 33 |
| BR/RS - SR Control | 36,814 | 6,554 | 9,579 | 1,884 |
| WL - SR Contaminated Floodplain | 183 | 4,005 | 43 | 15 |
| WL - SR Control | 108,276 | 35,834 | 46,065 | 1,900 |

### Regression Analysis[3]

*Figure 5. Muscle - Blood[4]*

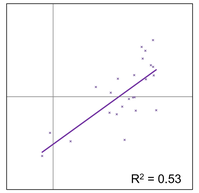



*All Breeds*




*Red Star*

*Figure 6. Feathers - Blood[4]*




*All Breeds*

*Red Star*

## DISCUSSION

### Potential Human Health Risk

- Risk calculations indicate that egg and muscle consumption are acceptable
- Hg concentrations in eggs and muscle do not suggest the need to restrict consumption
- Risk calculations for gizzard and liver require additional context (e.g., tissue-specific dietary consumption rates)
- Consumption of gizzard and liver acceptable to some degree

### Non-Lethal Sampling

- For some breeds of poultry (e.g. red star) blood sampling may serve as a useful surrogate for potential Hg exposure from ingestion of edible tissues
- Correlations less robust for other species / tissues

### Hg Depuration

- Feather-mercury data in some breeds (e.g., red star) suggests that loss of feathers could serve as a route for Hg depuration
- Depuration through feather loss has been observed in other species [e.g., eastern bluebird (Sialia sialis) (Condon and Cristol, 2009[5])]

[1] Worst case scenario
[2] Individual serving was assumed to be 4 oz.
[3] Log-transformed
[4] µg / g wet weight
[5] Condon, A.M. and D.A. Cristol. 2009. Feather growth influences blood mercury level of young songbirds. Environ. Toxicol. Chem. 28: 398-401