Mercury in the reservoirs: Water's OK, but don't eat the fish

Acknowledgement: This project is a slight adaptation of *Rising Mercury in Water*, An Interdisciplinary Lively Application Project, Project InterMath, available at http://www.projectintermath.org/docs/mercuryrising.pdf.

The Concern

Public officials are worried about the elevated levels of toxic mercury pollution in reservoirs providing drinking water to New York City. They have asked for our assistance in analyzing the severity of the problem. Scientists have known about the adverse affects of mercury to the health of humans for more than a century. The term "mad as a hatter" stems from the 19th century use of mercuric nitrate in the making of felt hats.

How does the Mercury get here?

Human activities are responsible for most of the mercury emitted into the environment. Mercury, a byproduct of coal, comes from acid rain from the smokestack emissions of old, coal fired power plants in the Midwest and South. Its particles rise on the smokestack plumes and hitch a ride on prevailing winds, which often blow northeast. After colliding with the Catskill mountain range, the particles drop to the earth[1]. Once in the ecosystem, micro-organisms in the soil and reservoir sediment break down the mercury and produce a very toxic chemical form known as methylmercury.

Biological Impact

Mercury undergoes a process known as bioaccumulation. Bioaccumulation occurs when organisms (including humans) take in contaminants more rapidly than their bodies can eliminate them, thus the amount of mercury in their bodies accumulates over time. If for a period of time an organism does not ingest any more mercury, its body content of mercury will decline. If, however, an organism continues to ingest mercury, its body content can increase to toxic levels. Humans can eliminate mercury in their system at a rate proportional to the amount remaining. Methylmercury decays by about 50 percent every 65 to 75 days if no further mercury is ingested during that time[2].

[1] Wayne A. Hall, "Mercury in the reservoirs: Waters OK, but dont eat the fish," The Times Herald-Record [Middletown, NY], 11 Jul. 1999, p. 6, cols. 1-4.

[2] According to the U.S. Geological Survey, the half-life of mercury in the human body is, on average, 70 days.

Safe Dose

Based on case studies and substantial human and animal data, the U.S. Environmental Protection Agency (USEPA) set the safe monthly dose for methylmercury at 3 micrograms per kilogram (μg/kg) of body weight[3]. This monthly dose is intended to protect the average adult person who weighs 70 kg.

Data

City officials collected and tested twenty (20) samples of bass from each of the affected reservoirs and have provided us with the data. All fish tested were contaminated. Your section has been assigned data from one of the sample reservoirs. The mean value of methylmercury in the fish samples was _____parts-per-million (ppm) or micrograms per gram (μg/g). The average weight of the fish was _____kg.

Exercise 1. The Neversink Reservoir advisory suggests that people consume no more than one fish per month. Does the advisory meet the EPA guidelines for methylmercury dosage?

Exercise 2. If each person adheres to the fish consumption restrictions as published in the Neversink Reservoir advisory and consumes no more than one fish per month, construct a discrete dynamical system model for the amount of methylmercury that will bioaccumulate in the average adult person. Assume a half- life of _____days. Use your model to determine the maximum amount of methylmercury the average adult human will bioaccumulate in his or her lifetime.

Exercise 3. What are the primary assumptions you made to develop your model in Exercise **??** (state at least two)? Revise one of your assumptions so that your model changes. Write a new model which differs from the original model due to the new assumption. How does this affect your answer to Exercise **??**?

Exercise 4. The toxicologist at Keller Army Community Hospital (KACH) provides you with the following information regarding the human health effects of mercury toxicity: Toxicity is defined using a term called LD_{50} – a somewhat scientific term which literally translates to "lethal dosage, 50th percentile." Simply put, LD_{50} is the dosage at which 50% of the humans exposed to a particular chemical will die. In our case, the term applies to oral lethal dosage and is expressed in milligrams per kilogram (mg/kg) of body weight. The LD_{50} for methylmercury is 50 mg/kg. According to your model from Exercise **??**, will the reservoir advisories protect the average adult from reaching the LD_{50}? What is the maximum number of fish the average adult can safely eat per month without ever bioaccumulating a lethal dosage of methylmercury?

[3]The USEPAs reference dose or safe daily dose (RfD) is actually 0.1 micrograms per kg of body weight per day.