MA103 PROJECT TWO

Background

In Project One, we investigated the bioaccumulation of methylmercury in the average adult who ate fish from the New York City reservoir system. In the problem set, we examined the potential impact of dumping mercury into the reservoir system. In this project, we will explore the effects of mercury when consumed by an average adult.

The Concern

Recall that public officials were worried about the elevated levels of toxic mercury pollution in reservoirs providing drinking water to New York City. Methylmercury affects the central nervous system, and in severe cases irreversibly damages areas of the brain.

Case Study

One of the most well documented cases of severe methylmercury poisoning occurred in Iraq in 1971. Hundreds of people died and many were hospitalized after eating bread made from wheat seeds imported from Mexico. The bread was made from seeds that were intended for planting and had been treated with a mercury fungicide. The sacks of wheat were marked with warnings written in Spanish, as well as skull-and-crossbones symbols. Neither of these warnings prevented the treated grain from being used to prepare homemade bread.

The bread contained an average of 7.9 parts-per-million (ppm) of methylmercury. Hundreds of people ingested lethal doses of methylmercury. No symptoms of mercury poisoning were experienced by any of the victims during the bioaccumulation period. Months after the consumption had stopped, the first symptoms of poisoning began to appear.

Biological Impact

Concentrations of mercury in the human body can be measured by analyzing hair or blood samples. Because hair grows about one centimeter per month, scientists use hair samples to reconstruct exposure levels. In 1973, hair samples were collected from exposed Iraqis. By measuring the mercury concentrations in each centimeter of hair from the scalp end, analysts gathered mercury concentration data for a two year period.

PART ONE

Requirement One

The table to the right lists the methylmercury concentrations during the period of consumption as indicated by the Iraqi hair samples. The data indicates the concentrations in ppm at the end of each week. Model the concentration, in ppm, of methylmercury in the hair samples as a function of a continuous time variable (t). Plot the data and your model on the same graph. Compare the data and your model and discuss the accuracy of your model to predict the data.

Week #	Dates (1971)	Mercury (ppm)
1	30 Oct. – 6 Nov.	
2	7 – 13 November	
3	14 – 20 November	
4	21 – 27 November	
5	28 Nov. – 4 Dec.	
6	5 – 11 December	
7	12 – 18 December	
8	19 – 25 December	
9	26 Dec. – 1 Jan.	

Requirement Two

a. Use the data to calculate the average rates of change over the following time periods:

(1) week #1 to week #5.
(2) week #2 to week #5.
(3) week #3 to week #5.
(4) week #4 to week #5.
(5) week #5 to week #9.
(6) week #5 to week #8.
(7) Week #5 to week #7
(8) Week #5 to week #6

Approximate the instantaneous rate of change of methylmercury absorption at the end of the 5th week. Explain (or show) the process you used to approximate this rate.

b. Using your continuous variable model, calculate the instantaneous rates of change of the concentration of methylmercury as detected in the hair samples at the end of each week.

c. Compare and discuss the instantaneous rate calculated by your model and the approximate rate determined from your data at the end of the 5th week.

Requirement Three

After ingesting the contaminated wheat, the first symptom to appear is usually paresthesia, a tingling and numbness of extremities. Subsequently, the more serious symptoms appear such as ataxia, a loss of muscular coordination; dysarthria, an inability to speak clearly; loss of vision; and death.

The levels at which the average person begins to experience the above symptoms are:

Symptom	Hair Concentration (ppm)
Paresthesia	250
Ataxia	400
Dysarthria	700
Blindness	1000
Death (LD_{50})	1600

Use your function model to predict when the average Iraqi ingested enough methylmercury to have experienced each of the above symptoms?

PART TWO

Requirement One

In January,1972, consumption of the contaminated wheat ended. The table to the right lists the methylmercury concentrations after consumption ended as indicated by the Iraqi hair samples. The data indicates the concentrations in ppm at the end of each month. Model the concentration, in ppm, of methylmercury in the hair samples as a function of a continuous time variable (t). Plot the data and your model on the same graph. Compare the data and your model and discuss the accuracy of your model to predict the data

Month (1972)	Hair mercury (ppm)
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

Requirement Two

a. Based on your model, what is the instantaneous rate of change of the concentration of methylmercury detected in the hair at any time t?

b. Use your function model to calculate the instantaneous rates of change of the concentration of methylmercury detected in the hair at the end of each month. Discuss the change in the rate at which methylmercury is being purged from the body over time.

Requirement Three

Recall from project one that the U.S. Geological Survey claims that the human body gets rid of enough methylmercury every seventy (70) days to reduce the body's concentration by one-half. Discuss whether or not your model supports this claim?

Requirement Four

The toxicologist at Keller Army Community Hospital (KACH) has informed us that the average adult will begin to show signs of improvement from methylmercury exposure when the concentration of methylmercury in the body falls below 500 ppm. When will this occur according to your model? What will the instantaneous rate of change of the concentration of methylmercury in the body be at the moment the concentration falls below 500 ppm?

FINAL REQUIREMENT

Prepare a one page executive summary, in memorandum format, for the New York City Department of Environmental Protection (NYCDEP) on your modeling and research efforts. Describe your major findings in this memo. Attach this memorandum to a complete report of your modeling and research efforts. This report should support your findings.

Additional guidance for written submissions, to include a sample memorandum, can be found on the MA103 Administrative Information page located at:

http://www-internal.dean.usma.edu/math/core/MA103/admin.htm