

Streams of Coal or Streams of Death? A Toxicology Case Study

by

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Part I— Remembering

The following case is based on a true story that took place around the year 1982.

Mary Beth watched the children splash in the cool, clear water of a stream at Yellow Creek State Recreation Park. She had stopped to take a short break on her drive home from college to her hometown in western Pennsylvania. This wasn't a holiday trip or even fall break; the fully loaded car told a different story. Mary Beth wouldn't be returning to school to finish the semester. Her mother had been diagnosed with cancer and Mary Beth was withdrawing from school to be with her during surgery and to help her through the grueling process of chemotherapy.

As Mary Beth watched the children play she recalled her own childhood and another stream that wove its way through her home town. Sulfur Creek, as it was called, had not been picturesque and Mary Beth had never played in it. Orange sludge coated the creek bed and stained the water. There were no fish, no insects, and no plants; nothing lived in Sulfur Creek. Along the banks, however, many residents had homes, including Mary Beth's family.

Questions

1. List as many concerns or questions that you would have if you were a resident of Mary Beth's hometown.
2. To whom would you look to address your concerns? How would you find answers to your questions?
3. Suggest possible explanations for the color in the water.

Part II—Black Lung

Mary Beth's hometown had been settled by Welsh coal miners that first staffed the deep bituminous coal mines that were the main source of employment in western Pennsylvania for many decades. The name of the town was Welsh for "streams of coal." These mines were also the source of the orange iron sulfate sediment that gave the stream its name. When the coal ore was brought to the surface it was crushed and the coal was separated from crushed rock waste. The rock waste or "spoil" was discarded in piles and, when exposed to water and oxygen, produced sulfuric acid. This, along with the sediment, had washed into the streams surrounding the mine.

The coal mines had already claimed the life of Mary Beth's dad. He had worked in the mines for 50 years. After many years of exposure to coal dust, he had suffered from coal miner's pneumoconiosis, also known as black lung. This disease is caused by breathing coal dust into the lungs. Her dad had caught a case of the flu, which turned into pneumonia, and he died of complications caused by his greatly diminished lung capacity.

Questions

1. Coal dust is an established toxicant. What is the dose, route of exposure and mechanism of action that causes black lung disease?
2. Is coal dust a chemical or physical toxicant? Explain.
3. Is coal dust a targeted or systemic toxicant? Explain.

Part III—Cancer Risk?

The Federal Coal Mine Health and Safety Act of 1969 recognized the cause of black lung and established safety and health standards for the mines, provided free chest X-rays, and set up a compensation fund for miners disabled by black lung. But the safety standards came too late for Mary Beth's dad. However, he did receive a monetary supplement to his normal pension check because of the severity of his disease.

Mary Beth wondered whether there were consequences for the other residents that had been exposed to the coal mines and the polluted run-off in Sulfur Creek. She recalled many times during her childhood when the water from her kitchen tap had smelled like rotten eggs, a possible sign of sulfuric acid contamination. There certainly had been a lot of people on her street that had had cancer; Mr. Stack, her mother's best friend Mrs. Kits, Mr. Slagle, their long time next door neighbor Martin Roberts and now her mother. That just seemed to her to be too much misfortune for one little street.

“Is my mother another victim of coal mining or is it just a coincidence that all these people on my street have had cancer?”

Questions

1. Do you agree with Mary Beth that something seems off-base with the number of cancer cases? How would you determine if there were more cancer deaths than could be accounted for by chance?
2. What information about Mary Beth's mother and the other victims of cancer would be needed for us to evaluate the cause of her cancer?
3. List potential carcinogens linked to coal mining and all possible routes of exposure.
4. What are the logical target organs for cancer related to coal mining? Can you think of others?
5. Describe a mechanism for one of the potential cancers that were suggested in questions 3 and 4.

Part IV— Epidemiology vs. Toxicology

Risk assessment is accomplished through the review of all available research data reported for a potential toxic compound. In cancer risk assessment two general types of research are conducted that provide the data for risk assessment: epidemiology and toxicology. The two research types approach the problem very differently, with each having both strengths and weaknesses.

Epidemiology

Epidemiologists are concerned with the study of outbreaks of disease that affect large numbers of people. They use sophisticated statistics, field investigations, and laboratory techniques to investigate the cause of a disease, its distribution, method of spread, and measures for control and prevention.

A mining area in western Pennsylvania was chosen for a retrospective case-control study. Epidemiologists collected data from death certificates for 178 individuals who died in 1981 and 1982. Cancer deaths and neighborhood (living) conditions were compared. The cases were matched with a control group of the same age, race, sex and residence type from an area without coal mining. To gain information on living conditions researchers interviewed neighbors and family members of the deceased.

Epidemiology Questions

1. List the specific strengths and weaknesses of this study.
2. List the general strengths and weaknesses of epidemiology for providing an answer to Mary Beth's question.

Toxicology

Toxicologists study poisons or toxins by detection, isolation, identification, and determination of their effects on the human body. However rather than looking at retrospective (past) data as the epidemiologist does, they utilize bioassays. Bioassays test the effects of toxins on living model organisms that are not human.

One hundred fifty mice were randomly assigned to three groups. The control group received normal drinking water. One treatment group received drinking water taken from a coal mining town in eastern Ohio while the other received water taken directly from a stream contaminated with mine run-off. Mice were given their specific type of water to drink for the entire length of the experiment. Mice were monitored for 12 months and all health problems and deaths recorded. At the end of the experiment the mice were necropsied and examined for any evidence of health effects or tumors.

Toxicology Questions

1. List the specific strengths and weaknesses of this study.
2. List the general strengths and weaknesses of toxicology for providing an answer to Mary Beth's question.

Part V— Research Analysis

Your instructor will assign a research paper for you to read. Analyze the paper by answering the following questions.

Questions

1. What prior research led to the research described in this paper? What was already known about the topic and what needs to be better understood?
2. What is the research question? What was the approach the authors took to answer this question?
3. What organisms are used in this study and why were they chosen?
4. What are the controls and how were they chosen?
5. Describe the basic methods used in this research.
6. What challenging situations arose before or during the completion of the project?
7. Be able to discuss the purpose of each figure or table in the paper.
8. Describe the main scientific conclusions of this research. Indicate which table or figure shows the data that support each conclusion.
9. What do the authors themselves admit are weaknesses of the experimental design?
10. What could be done to improve the accuracy of the results?
11. What is the “take-home” message from this research? Did the authors answer the question they set out to address?

Part VI—Decision Time

A year had passed since Mary Beth first withdrew from school. She had resumed her studies and was walking across campus toward her next class while talking with her mother on a cell phone. She was overjoyed to hear the doctor's report that her mother's tumor seemed to be completely gone and there were no abnormal cells in her mother's lymph system. This meant that the cancer did not metastasize or spread to other parts of the body. The doctor planned to continue following her progress but was fairly confident that the cancer had been cured for good. Mary Beth was relieved, although she was still angry about the coal mines.

"The coal mines may have given my mother cancer but at least she'll survive, unlike my dad."

Question

1. With all that you have learned from the two research articles and other readings do you agree with Mary Beth that her mother's cancer can be blamed on the coal mines? Justify your answer.

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