Determination of Radioactive Emissions from Coal-fired Power Plants in Indiana

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Introduction

In a recent visit to Ball State University, Dr. Hugh Spencer, a professor of environmental engineering at the University of Louisville, pointed out that in the last 50 years, coal-fired electric plants along the mainstream of the Ohio River have increased from 200 MWe to approximately 30,000 MWe. It is well known that coal-fired power plants emit pollutants into the air. Some of these pollutants are radionuclides that are contained in the coal that is burned. Two separate studies of radionuclides from coal-fired power plants produced conflicting results. Keiger and Jacobs (1) studied samples of coal, flyash, bottom ash, and scrubber sludge collected from different regions of the United States. These samples where analyzed for radium, thorium, and uranium and showed no immediate health risk. On the other hand, a similar study by Styron and Robinson (2) conducted in Miamisburg, Ohio, indicated that a hazard does exist and further studies should be made.

In view of these conflicting reports it was decided to investigate the release of radioactive nuclides by coal-fired power plants in Indiana. Our sampling technique was the collection of air samples via high volume air sample filter papers in the vicinity of coal-fired power plants.

Experimental Procedures

In selecting sampling locations in Indiana we chose Ball State University and Indiana University because it was easy to put the air sampler near the smoke stacks of the power plants in these locations. These locations are not electric plants, but instead produce steam for heating. Since coal burning in these plants is the same as in electric plants they can be studied for emissions from coal-burning. The Fairbanks 400 MW Breed plant was also chosen because it was isolated from other power plants. It is located southwest of Terre Haute. Despite the cooperation of the Indiana and Michigan public relations officer in Muncie, the power plant officials would not allow air samples to be collected on the grounds of the Fairbanks plant. A neighbor allowed the air sampler to be set up in his yard which was within two miles of the Breed plant.

The final sampling location was in Markleville. The Markleville area doesn't contain a power plant and was used as a control sample for comparison with sampling sites close to coal-fired plants.

Detailed data on each plant is given in Table 1. Indiana University and Fairbanks both use mechanical dust collectors and electrostatic precipitators. Ball State has no emission control system.

The sampling system consisted of a high volume air sampler redesigned for easy transportation to the different sites. At each location, a preweighed filter was placed in the sampler and exposed continuously for seven days. An average of 0.6 grams of particulate matter was collected in each sample. Filters were folded to a three inch square and taped to a lithium drifted germanium detector. Gamma spectra were collected for forty eight hours in a Nuclear Data 4410 multichannel

TABLE 1 *Data on coal-burning plants sampled*

Plant	Ball State	Indiana University	Fairbanks
Type of System	¾ x #10 mesh coal	1¼ x #10 mesh coal, Hoffman spreaders	Pulverized coal
Efficiency Rating	75%	85%	35%
Type of Emission Control	None	Mechanical dust collector Electrostatic precipitators	Mechanical dust collector Electrostatic precipitators
Type of Coal	Indiana (High Sulfur) Washed	Indiana (2.5% Sulfur) Washed	Indiana Coal Unwashed

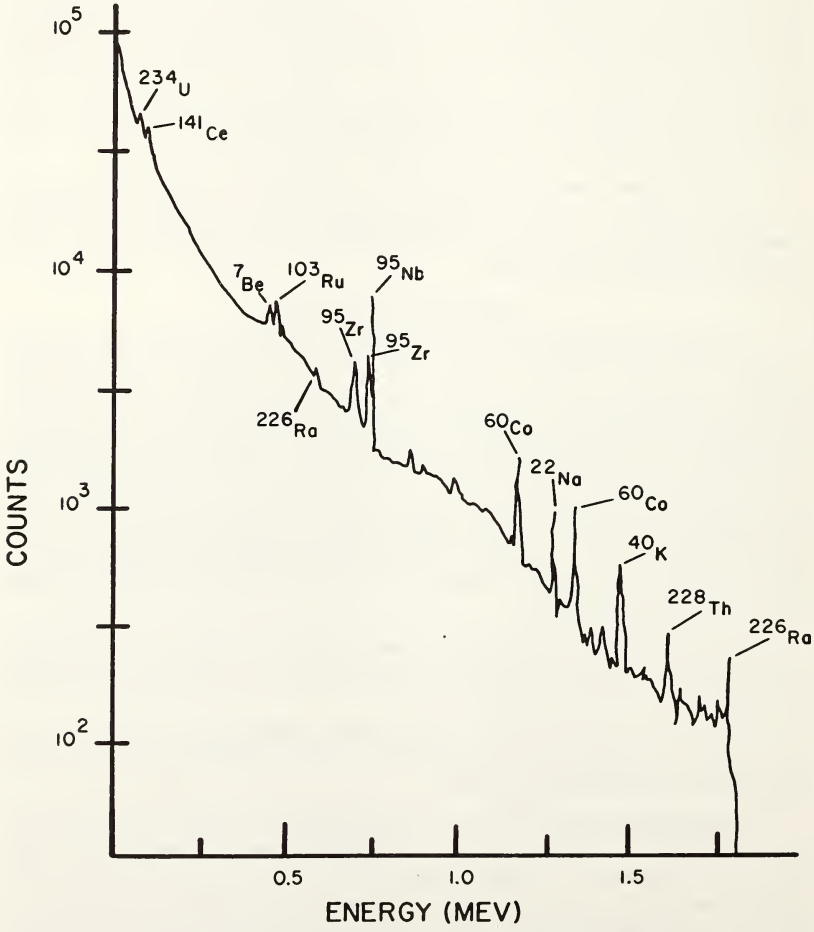

FIGURE 1: *Gamma spectrum of air filter sample from Ball State University*

analyser and transferred to Ball State's Dec System 10 computer for later analysis. The system was calibrated using standard sources of ^{60}Co, ^{22}Na, and ^{137}Cs. A plot of a typical spectrum is shown in Figure 1. Isotopes present in the samples were identified by the energies of their characteristic gamma rays. All gamma-ray peaks were corrected for the efficiency of the lithium-drifted germanium detector. The area under each gamma peak was calculated by the subtraction of a linear background by means of a least squares fit. The activity measured by the areas under the peaks was normalized to the potassium (^{40}K) gamma peak, which was contained in the lab and was constant for all spectra including laboratory background.

Results and Conclusions

^{22}Na, ^{60}Co, and ^{40}K were known to be present in the laboratory background. The ^{7}Be that is present in the spectrum is produced in the atmosphere by cosmic radiation. The isotopes ^{144}Ce, ^{103}Ru, ^{95}Zr and ^{95}Nb are fission fragments which are produced in nuclear fission reactions. Since there are no nuclear power plants in the vicinity of the sampling locations, these fission fragments are most likely due to atmospheric nuclear testing. The age of the fission fragments was calculated from the relative abundances of ^{95}Zr and ^{95}Nb and it was concluded that these isotopes were produced by an atmospheric test by the People's Republic of China on October 16, 1980.

The characteristic activities produced by emissions from coal-fired plants are those of ^{234}U, ^{228}Th, and ^{226}Ra. These long-lived isotopes are trapped in the coal and released as it is burned. These results are presented in Table 2 and quoted errors are due to counting statistics only. The overall uncertainty for error in this study is estimated to be 10%. This includes errors from the geometry of fitting the curve, the efficiency curve of the detector, and the amplifier gain shift in analyzing one of the samples.

The heavy elements ^{226}Ra and ^{228}Thorium were present in the laboratory background and result from the cinder block construction of the building but all samples show an increase in activity due to these isotopes. The ^{234}U activity appears to be a function of distance from the emitting stack. The activity in the Ball State sample which was the closest to the stack was the highest, and the Fairbanks sample, taken almost 2 miles away, showed nothing. The high values for ^{228}Th and ^{226}Ra in the Markleville sample indicate the possibility of their presence in the soil of the region. The larger concentrations of ^{226}Ra at the Ball State plant appear to indicate the need for a pollution control system. The ^{226}Ra and ^{228}Th activities at

TABLE 2 *Heavy Elements*

	^{226}Ra	^{228}TH	^{234}U
BALL STATE	1.582 ± .019	.784 ± .058	.293 ± .005
MARKLEVILLE	1.013 ± .038	.67 ± .016	.075 ± .005
INDIANA UNIVERSITY	.785 ± .036	.330 ± .053	.130 ± .008
FAIRBANKS	.754 ± .037	.517 ± .028	–
LABORATORY BACKGROUND	.466 ± .089	.435 ± .036	–

Indiana University and Fairbanks could not be detected in amounts significantly above background. This can be attributed to their emission control systems which seem to be working.

In general the activities of fission fragments from bomb testing were overwhelmingly greater than those produced by the emissions of coal fired power plants. Therefore, at this time there appears to be no environmental health risk as a result of radionuclide emissions from coal-fired power plants that use appropriate emission control systems. It appears that the atmospheric denotation of nuclear weapons is more of an immediate radiological health hazard than the burning of coal. As we increase our dependence on coal, particularly western coal, close monitoring should be maintained. Further studies of the effects of emission controls on the release of radioactive isotopes to the environment should prove instructive in the design of these systems.

Literature Cited

1. KRIEGER, H. and B. JACOBS. 1978. Analysis of radioactive contaminants in by-products from coal-fired power plant operations. EPA/600/4-78/039, Washington, D.C.
2. STYRON, C.E. and B. ROBINSON. 1977. Preliminary radiological impact assessment of western coal utilization. MLM-2470(OP), Washington, D.C. 3p.