

MLM-2470(OP)

A PRELIMINARY RADIOLOGICAL IMPACT ASSESSMENT OF WESTERN COAL UTILIZATION*

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CONF-771113--7

ABSTRACT

Western coal is expected to play an increasingly important role in meeting national energy needs, largely because of its abundance, accessibility, and low sulfur concentration. However, Western coal is comprised largely of subbituminous and lignite ores, which have a higher geochemical affinity for uranium than Eastern coal.

This research program was initiated to: 1) delineate the scope of the potential environmental and human health problem associated with radioactivity in Western coal; 2) establish a data base for ²³⁴U, ²³⁸U, ²¹⁰Pb, ²¹⁰Po, ²³⁰Th and ²²⁶Ra found in Western coal; 3) study the release, fate, and accumulation of radionuclides from a power plant burning Western coal; and 4) assess the possible need for additional control technology and/or standards.

Preliminary results indicate that radionuclides may be made available to the environment from burning Western coal. Lead-210 in coal used at the power plant averaged 0.79 pCi/g, ²¹⁰Pb in soil averaged 0.70 pCi/g, and ²¹⁰Pb in/on vegetation in the environs of the power plant ranged from 2.23 to 5.70 pCi/g. These values for ²¹⁰Pb in soil are in the range of natural background, but plants appear to have slightly elevated concentrations. Preliminary dose evaluations for ²¹⁰Pb alone indicated that individuals whose total vegetation intake was grown in this area could receive as much as 400 mrem/yr to the kidney, which is below the current standard of 500 mrem/yr. Although no health hazard has been identified, additional studies of ²¹⁰Pb concentrations in/on vegetation and of dose evaluations are being undertaken. It is important to note that the power plant has not been directly implicated as the sole source of these radionuclides in diffusion modeling studies.

from coal-fired power plants, and these particles most easily pass through conventional particulate control devices. Billings et al. (7) indicated that about 90% of the mercury in coal burned in a pulverized coal furnace appears as vapor in the flue gas. Enrichment of soil and vegetation in lead has been reported at the Four Corners Plant in New Mexico (8). Thus, the process of coal combustion releases trace elements to the atmosphere as vapors and particles. These particles have relatively greater concentrations of certain trace elements than the feed coal (9) or the collected fly ash. Western coal reserves are also known to contain uranium and its decay products at 10 to 100 times greater concentrations than most Eastern coal (4, 10-11). Uranium is found chiefly in low-rank and impure coal, including lignite, subbituminous coal, and carbonaceous shale of the northern Great Plains and Rocky Mountains regions (4).

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APPROACH

A preliminary phase has been incorporated into the experimental design to identify those areas of most critical concern and to optimize research efforts for assessing potential radiological impact of increased Western coal utilization. Samples of coal from major Western mines, as well as samples of coal, ash, stack effluents, air (airborne particulates), soil, and vegetation associated with a power plant using Western coal, were prepared radiochemically and analyzed by alpha pulse height spectroscopy. Details of stack sampling and radionuclide analyses are given by Farmer et al. (12). The data were then used in a preliminary effort to calculate the radionuclide balance for the power plant and to model radiation dose to the population adjacent to the power plant.

PROGRESS AND RESULTS

During the past year procedures were developed or modified for analysis of ²³⁴U, ²³⁸U, ²¹⁰Po, ²¹⁰Pb, ²²⁶Ra, and ²³⁰Th in coal, ash, soil, vegetation, and air (airborne particulates). An integrated quality control program, operational sheets for collection of samples, and analytical logbooks were developed to ensure consistency and validity of data. Major Western mines were identified, and samples were collected from the mines and at a power plant using coal from one of the mines. All samples were analyzed for ²³⁴U, ²³⁸U, and ²¹⁰Po; coal from the power plant was also analyzed for ²¹⁰Pb; and stack gases were analyzed for ²²²Rn. Analyses for ²²⁶Ra and ²³⁰Th in samples are in progress, with some additional analyses for ²¹⁰Po and ²¹⁰Pb. Samples of coal contained ²³⁴U and ²³⁸U ranging from 0.04 to 1.20 pCi/g and ²¹⁰Po ranging from 0.12 to 2.05 pCi/g (Figure 1). These radionuclide concentrations in Western coal from operating mines are roughly comparable to values for Eastern

THE U.S. GOVERNMENT'S DESIRE TO REDUCE DEPENDENCY ON imported fossil fuels, as well as other factors, is moving the United States toward an economy based on coal as the primary fossil fuel (1)***. Use of coal as a fuel is expected to triple between 1975 and 2000, from approximately 10 quads (1 quad = 10¹⁰Btu) to 30 quads (2). It seems almost certain that the country will turn increasingly to the vast coal deposits of the western states, since Western coal reserves (198 billion tons) represent 72% of the identified United States coal resources and this coal has a low sulfur concentration (3). Furthermore, 50% of the coal minable at current prices is located in the West (4).

Governmental agencies, environmentalists, and scientists have become increasingly concerned with potential problems associated with large additions of trace elements in the environment from burning fossil fuels (5). Natusch et al. (6) have reported that preferential concentration of the trace elements As, Sb, Cd, Pb, Ni, Se, Tl, and Zn occurs in the smallest particles emitted

*Research sponsored jointly by the U. S. Department of Energy and Environmental Protection Agency.

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coal as reported by Bedrosian (13), Martin (14), and an EPA survey (15). Western coal reserves, however, are reported to have significantly higher concentrations, on the order of 10 to 100 times (4). It is also interesting to note (Figure 1) that disequilibrium exists in the uranium decay chain for Western coal. The ratio of ^{210}Po to uranium varies from 1.4 to 12.6 as the grade of coal declines. Thus, surveys of radionuclides in Western coal reserves based solely on uranium may have appreciably underestimated total radionuclide content of these coals. This does not create a problem for coals being mined today, but it is recommended that some caution be used in assaying coal reserves for radionuclides.

A calculation of the radionuclide balance for Unit 2 of the power plant was made to check the consistency of the measured data and to gain an insight into the pathways of radionuclides within a coal-fired power plant. Table 1 shows radionuclide values for coal burned at the plant during the gathering of data for the balance exercise. The relative imbalance ranged from -15 to +14% for the four radionuclides, and this is considered to be an acceptable range in light of the error generally associated with stack sampling. Fly ash and bottom ash are enriched in radionuclides, with more than 70% of each radionuclide appearing in the fly ash. The stack output represents a relatively small percentage of the total output and, therefore, has a relatively small effect on the balance.

Data for stack effluents were used in atmospheric diffusion modeling to predict deposition of radionuclides on soil and vegetation, concentrations in air, and dose commitments to man for comparison with measured concentrations of radionuclides (Table 2). This exercise gives some insight into the contribution of power plant stack effluents to radionuclides in the immediate environment. The maximum deposition on soil from the plume for 20 yr operation is less than 1% of radionuclide concentrations measured in soil. Predicted values for ^{234}U and ^{238}U on vegetation are slightly

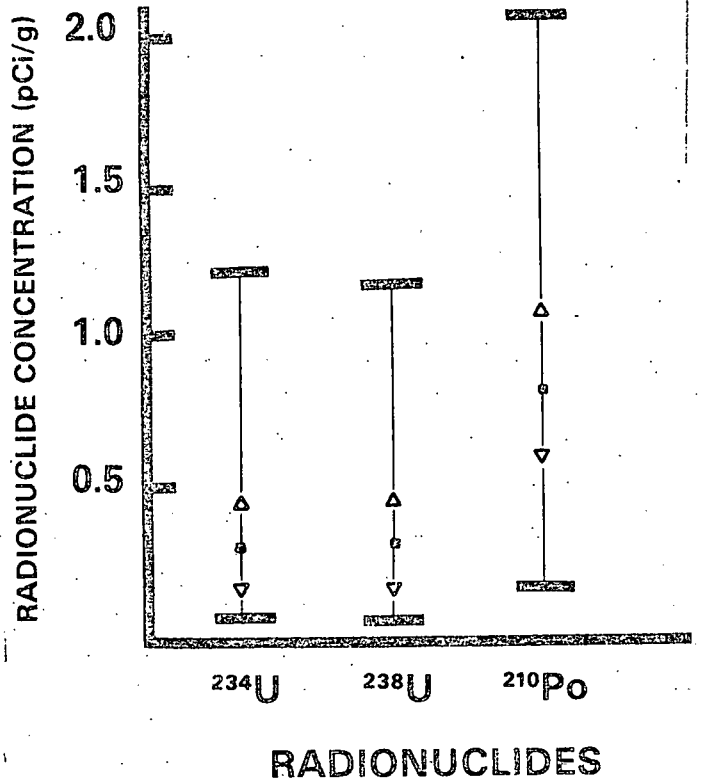


Fig. 1. - Radionuclides in Western coal from 19 mines varied widely. (For ^{234}U , 1 pCi/g = 0.16 ppb; for ^{238}U , 1 pCi/g = 3.0 ppm; for ^{210}Po , 1 pCi/g = 0.22×10^{-3} ppt.)

Table 1 - Preliminary Radionuclide Balance for a Power Plant Burning Western Coal

Compartment	Radionuclides (pCi/sec)			
	^{234}U	^{238}U	^{210}Po	^{210}Pb
Input				
Coal (combusted at 107 kg/sec)	17843	16793	29388	29388
Output				
Stack gas and particulates (437 m ³ /sec)	2644	2665	3241	5160
ESP ash	15849	15376	19302	20938
Bottom ash (12.76%)	1446	1350	2685	2993
Sum of output	19939	19391	25228	29091
Relative Imbalance*	-12	-15	+14	+1

*Relative Imbalance (%) = $\frac{\text{input} - \text{output}}{\text{output}} \times 100$

Table 2 - Measured and Predicted* Values for Radionuclides in the Environment

	²³⁴ U		²³⁸ U		²¹⁰ Po		²¹⁰ Pb	
	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted
Air (aCi/m ³)	49	215	54	217	1,207	264	24,221	399
Soil (pCi/g)	0.67	0.006	0.86	0.006	1.85	0.0002	0.70	0.001
Vegetation (pCi/g)	0.009	0.006	0.010	0.006	0.120	0.0002	2.230	0.001
Stack (pCi/m ³)	9.83		9.77		9.75		18.83	
²¹⁰ Pb Dose Calculated from Measured Concentrations, for Ingestion Pathway, for Kidney (mrem/yr)							400	
²¹⁰ Pb Dose Calculated from Predicted Deposition, for Ingestion Pathway, for Kidney (mrem/yr)								0.24

*Predicted values were derived from atmospheric diffusion model.

below measured values; predicted ²¹⁰Po is 0.17% of measured concentration; and ²¹⁰Pb is 0.047% of measured concentration. The dose to man from ingestion of vegetation grown in the area, as predicted from stack effluents, is 0.06% of the dose calculated from ²¹⁰Pb concentrations measured in vegetation. It can be safely concluded from this inconsistency in measured vs predicted values that preliminary data do not point to the power plant stack effluent as the major source of these environmental radionuclides. Considerable attention in continuing studies will be given to testing this conclusion and to investigating other possible sources of radionuclides, such as the ash pond.

SUMMARY

Preliminary results do not indicate a health hazard from burning Western coal in a modern power plant, but additional studies are planned test field data on possible biomagnification of radionuclides in the food chain and to assess implications of fly ash utilization.

Subsequent studies will also consider movement of radionuclides from ash ponds and coal cleaning refuse piles. Lee et al. (16) have suggested that evolution of ²²²Rn from ash ponds will constitute the most significant radionuclide problem in the fossil fuel cycle. Furthermore, the potential ²²²Rn dose to the public from use of fly ash in bricks and cement blocks for construction of homes will be evaluated.

Additional pathways to man and biogeochemical cycles are to be investigated.

Inconsistencies in predicted vs measured environmental radionuclide concentrations are to be resolved.

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