MEASUREMENT OF AIRBORNE FALLOUT IN NORTH FLORIDA FROM THE CHERNOBYL REACTOR ACCIDENT

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ABSTRACT: *Air samples were measured in Tallahassee to monitor fallout from the Chernobyl reactor accident, which occurred April 26, 1986 at 1:23 AM. One set of air samples was collected from April 30, 1986 through May 23, 1986 to measure γ-ray activity, and another set was collected from April 30, 1986 through June 6, 1986 to measure total β activity. ^{131}I and ^{137}Cs were observed in the γ analysis, with ^{131}I peaking on May 9 at 0.7 ± 0.1 pCi/m^3 and ^{137}Cs May 12 at 0.40 ± 0.05 pCi/m^3. The ^{137}Cs was, however, also present as room background, most likely the result of past above-ground nuclear tests. Tallahassee gross beta activity had large daily fluctuations indicating that this is not a good indicator of increased radioactivity at the levels measured. Data from Orlando are also presented (^{131}I) along with a brief listing of radionuclides and amounts detected in other U.S. cities for comparison. The fallout from Chernobyl did not present a health hazard to the population of Florida.*

THE Chernobyl graphite-moderated reactor accident April 26, 1986 has generated considerable concern in the U.S. over what fallout, if any, would reach this country and what danger it would present to public health. Having the facilities at Florida State University to collect air samples, and photon detectors with sufficient resolution to perform trace element analysis, a unique opportunity existed to monitor local air for any fallout reaching the city. However, the short notice given for preparation did not allow time to optimize the γ-ray experimental setup with respect to data storage and elimination of room background. Given the estimated time of 2 weeks for the radioactive cloud to reach Florida, collection of samples was begun April 30th in Tallahassee to monitor total β as well as ^{131}I and ^{137}Cs γ-ray activity.

The decision to look mainly for ^{131}I and ^{137}Cs out of the large number of fission products and transuranium elements released was based on analysis of an accident which occurred at a similar reactor, the Windscale graphite-moderated plutonium production reactor in England October 9, 1957. It was found that ^{131}I was the major radioactivity deposited on the ground in areas far from the reactor site (American Physical Society, 1985). Table 1 shows all radionuclides substantially produced in that reactor (>1 kCi) whose release to the atmosphere was estimated at $>1\%$. ^{132}Te also emits γ-rays but its half-life ($t_{1/2} = 78$ hours) is too short to allow much to reach Florida.

MATERIALS AND METHODS—Air samples in Tallahassee were collected starting April 30, 1986. For γ-ray detection, samples were collected on Nuclepore filters with an active area of 132.7 mm^3 and 0.4 μm pore size, which are generally regarded as totally retentive for atmospheric particu-

TABLE 1. Estimated radiation releases >1% of inventory from Windscale, October 9, 1957 (taken from APS Study, 1985)

Isotope	$t_{1/2}$	Decay Modes
^{85}Kr	10.7 yr	β^-; no γ
^{131}I	8.05 d	β^-; γ (364.5 keV)
^{132}Te	3.25 d	β^-; γ (many energies)
^{133}Xe	5.25 d	β^-; no γ
^{137}Cs	30.17 yr	β^-; γ(661.7 keV)

late matter. A rotary air sampler of F.S.U. design was employed to put new filters in place automatically every eight hours. While this time resolution was not desired, it was used to prevent clogging of the filter membrane by particles other than those due to the fallout. Air was drawn through the filter paper by a diaphragm pump at the rate of 4 liters/min or 1.9 m^3 air/filter. Three such filters constituted 1 day of sampling, from 9 AM to 9 AM Eastern Standard Time, taken on the seventh floor balcony of the Keen Building at Florida State University with the exposed filter surface pointing downward.

Sample counting was done using an Ortec lithium-drifted germanium detector (Ge(Li)) with an active volume of 125 cm^3 and efficiency rating of 25.6% at 1332 keV relative to NaI. Each day, three filters were taped to the front face of the detector (except on weekends when two days of samples were collected) and counted for 24 hours. The detector was placed in an array of 10 cm thick lead bricks, surrounding and in front of it, to reduce a relatively large room background due to ^{232}Th, ^{238}U and ^{40}K γ-rays. Energy and efficiency calibrations were made using a ^{152}Eu source and a 1.18μCi ^{137}Cs source, respectively. All energy spectra were measured using a 4096-channel analyzer. Net counts for ^{131}I and ^{137}Cs were obtained starting May 4. Room background was measured May 17 and May 19; the May 9 sample was recounted May 22 for comparison.

Total β activity was measured on one 8-cm^2 active area filter paper per day. Here the flow rate was 20 m^3/day and the air was collected atop the Tallahassee Office of Radiation Control building. Each sample was counted in a gas proportional chamber 5 hours after it was removed. This was done to allow the radon daughters to decay out. A ^{90}Sr source was used for efficiency calibration. Samples counted on Mondays corresponded to 3-day averages.

RESULTS AND DISCUSSION—Figure 1 shows γ-ray activities for ^{131}I and ^{137}Cs measured in Tallahassee. ^{131}I peaked May 9 at 0.7 ± 0.1 pCi/m^3(1pCi = 10^{-12} Curies). The next two days' samples were counted together. Figure 2 shows portions of γ-ray spectra showing ^{131}I and ^{137}Cs May 10-11, as well as ^{137}Cs in room background; the other peaks come from room background and correspond to the natural radioactive decay series ^{232}Th and ^{238}U, present in the masonry walls.

Figure 3 shows Orlando ^{131}I γ-ray data (Office of Radiation Control, Department of HRS). Activity peaked May 13-14 at 1.1 pCi/m^3 and reappeared May 21. Although not shown in Figure 1, ^{131}I may have reappeared in Tallahassee May 16 in very small amounts (≤ 0.2 pCi/m^3) which would follow the Orlando pattern. However, even though the Tallahassee and Orlando peaks occurred 2-3 days apart, this should not be used to represent the gross movement of airborn radionuclides. Local weather variations are probably what determine the time at which the peak activity will occur at a given altitude. Air samples from Jacksonville also showed ^{131}I, detected at 0.55 pCi/m^3 May 11 (Environmental Protection Agency Report, May, 1986).

Compared to the sudden appearance and gradual disappearance of ^{131}I, identification of the ^{137}Cs activity as fallout is not certain due to the constant

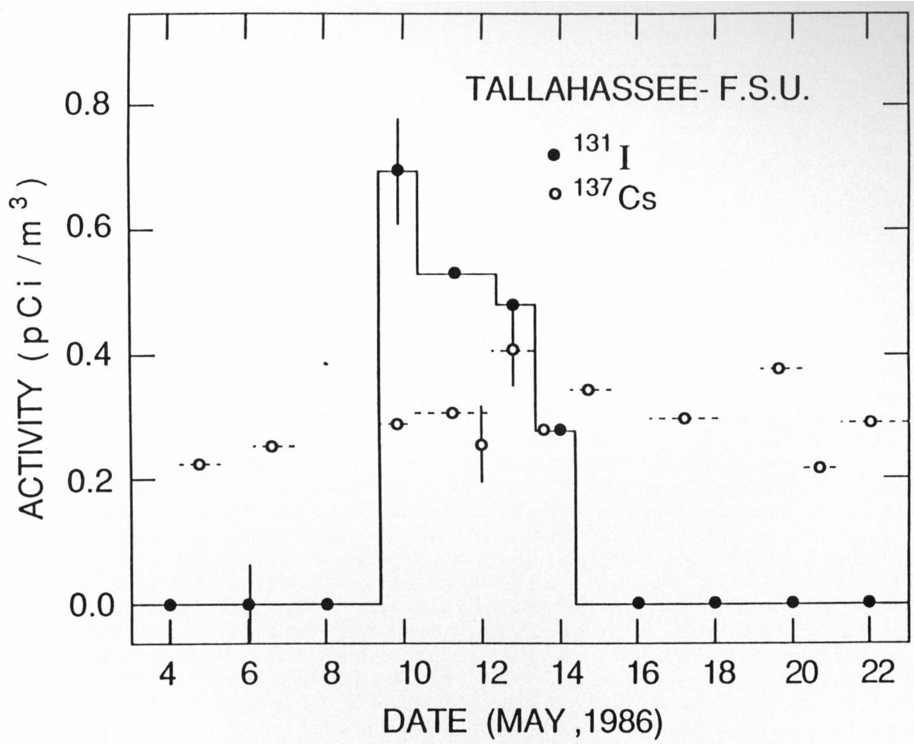

FIG. 1. γ-ray activities for ^{131}I and ^{137}Cs measured in Tallahassee. Zero levels for ^{131}I are marked every other day although monitored daily. The horizontal dashed lines for ^{137}Cs represent one or 2 days collection, from 9 AM to 9 AM. Error bars shown represent all single day data points. The ^{137}Cs room background is shown on 5/12/86 with no horizontal bar.

room background present, probably due to atmospheric test residues from the 1950's and 1960's.

Figure 4 shows total β activity in Tallahassee, and this should be compared with Figure 1. While total β activity peaked May 13, 1 day after ^{137}Cs and 3 to 4 days after ^{131}I, no conclusion can be drawn from this as to the source of increased activity. The wildly varying β activity data merely indicates the necessity of γ-ray analysis when monitoring for changes in environmental radiation levels for particular nuclei.

COMPARISON WITH OTHER U.S. CITIES—^{131}I was reported in many locations during May. To compare amounts with Florida's data, as of May 19, 1986, levels in air reached a reported relative high of 1.6 pCi/m^3 May 12 in Phoenix, Arizona (EPA, 1986). As stated above, ^{131}I and ^{137}Cs were looked for using past results as a guide. To ascertain what other isotopes could have reached Florida and warrant monitoring, Table 2 shows a list of radionuclides other than ^{131}I along with locations, dates and amounts measured (EPA, 1986). Besides ^{132}Te already mentioned, ^{103}Ru, ^{134}Cs and ^{99}Mo were also re-

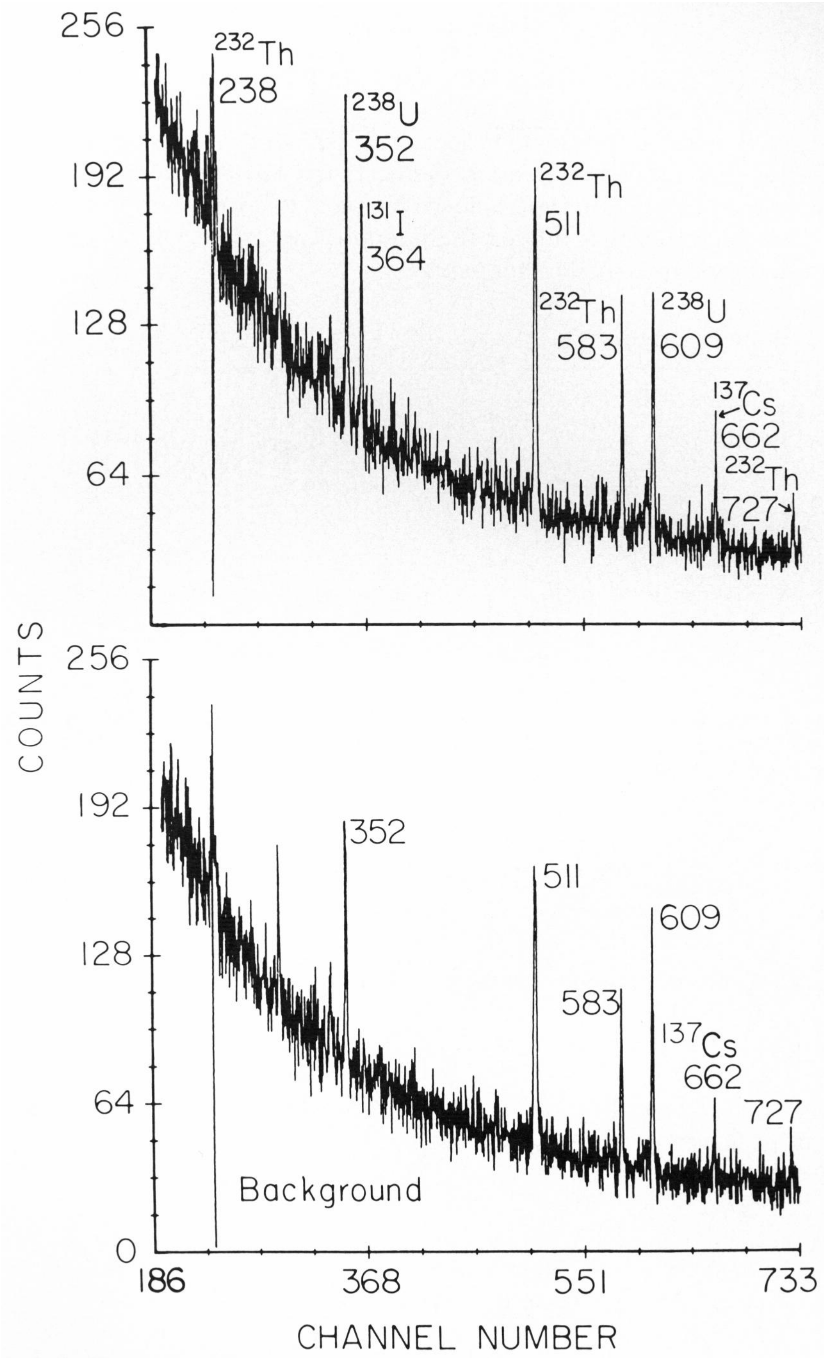

FIG. 2. The upper spectrum shows a portion of the γ-ray activity of air samples May 10-11, 1986, showing ^{137}Cs and peak ^{131}I concentration. The lower spectrum shows ^{137}Cs present in the room background along with ^{232}Th and ^{238}U decay series γ-rays. Note the absence of the 364 keV ^{131}I line in the bottom spectrum.

leased at Windscale. Neither ^{103}Ru nor ^{99}Mo were seen in Tallahassee, but ^{134}Cs, with 2 γ rays at 605 and 796 keV, may have been present because both energies correspond to unknown peaks on certain days of analysis. Table 2 indicates that substantially more radioactivity was detected in Idaho and New Mexico. Some stations employed charcoal to collect airborne iodine. It has been suggested that this substrate retains two or more times as much of the volatile iodine than do filter papers.

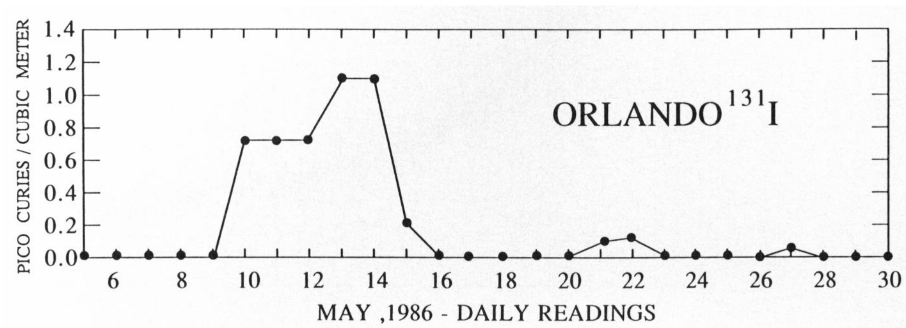

Fig. 3. Orlando ^{131}I γ-ray data (furnished courtesy of HRS, Tallahassee, FL). The activity peaked May 13 at 1.1 pCi/m^3 and again on May 22 at 0.14 pCi/m^3. Data points for May 19 and May 26 are 72-hour averages.

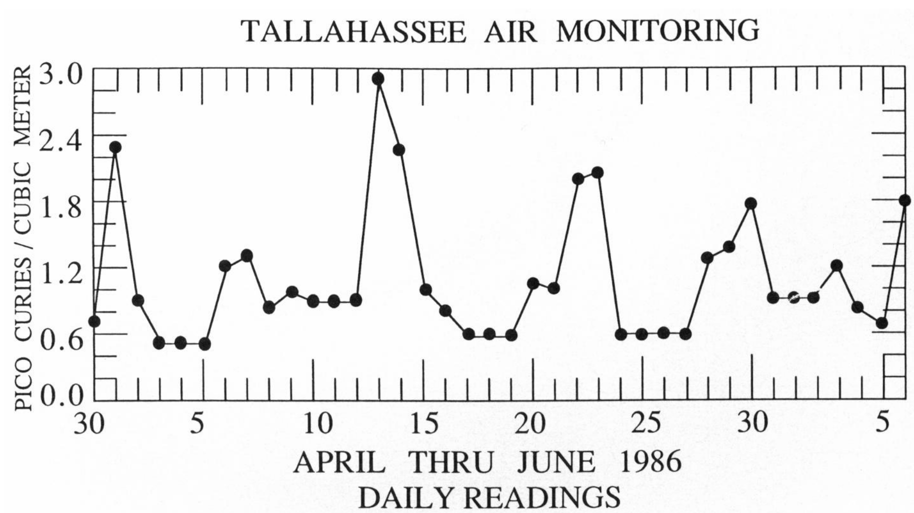

Fig. 4. Total β activity in Tallahassee (furnished courtesy of HRS, Tallahassee, FL). The peak activity of 2.9pCi/m^3 observed on May 13 may or may not have been due to Chernobyl fallout. Data points on May 5, 12, 19, and June 2 are 72-hour averages; that for May 27 is a 96-hour average.

TABLE 2. Radionuclides detected in air (unless otherwise noted) at particular U.S. monitoring cities. ^{131}I not included (from EPA Reports, May 1986)

Location	Isotope	Activity (pCi/m^3)	Date (1986)
Phoenix, Arizona	$^{134,137}Cs$	0.015, 0.28	May 8
Denver, Colorado	^{134}Cs	0.0002	May 6
Idaho Falls, Idaho	^{99}Mo	130 pCi/l*	May 8
Santa Fe, New Mexico	^{103}Ru	28 pCi/l*	May 9
El Paso, Texas	^{140}Ba	0.021	May 10
	^{137}Cs	0.059	
Richland, Washington	^{132}Te	0.02	May 8
	^{103}Ru	0.02	
	^{137}Cs	0.028	

*Rainwater.

CONCLUSIONS—It appears that graphite-moderated nuclear reactor type radiation releases are best observed by monitoring airborne ^{131}I levels. Although several radionuclides were detected at different sites, iodine is by far the most often reported. This is probably due to a combination of factors. First, a large amount of iodine is released from the source. Second, iodine has a long enough half-life to allow it to be transported considerable distances without its activity severely decreasing. Finally, the volatile nature of this element may be important to the transportation mechanism.

Concern in Florida for exposure to fallout is due to its biological effects if taken internally. ^{131}I in the human body has an effective $t_{1/2}$ of 7.6 days, the critical organ being the thyroid from its chemical need for iodine as a mineral (critical organ is that organ considered to suffer greatest radiation damage). ^{137}Cs has an effective $t_{1/2}$ of 70 days with the whole body (bone marrow, organs) considered critical (Choppin, 1985). The Department of Health and Rehabilitative Services in Florida (1985) defines exposure limits for the general public to concentrations in air of soluble plus insoluble ^{131}I (^{137}Cs) as 1.01×10^4 pCi/m^3 (2.5×10^3). The detected values in Florida were thus 10,000 to 100,000 times below these standards and presented no danger to public health. The recommended protective action guideline for milk levels of ^{131}I is 15,000 pCi/l. A maximum of 30 pCi/l was found in Florida milk and again presented no danger to public health.

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Biological Sciences

SCORPION, PSEUDOSCORPION, AND OPILIONID FAUNAS IN THREE CENTRAL FLORIDA PLANT COMMUNITIES

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Abstract: *Ground surface populations of scorpions, pseudoscorpions, and opilionids were studied for one year using pitfall traps set in pond pine, sand pine scrub, and flatwoods communities in central Florida. Forty-two scorpions (1 species), 41 pseudoscorpions (5 families and 6 species), and 248 opilionids (2 families and 3 species) were collected.*

Very little research has been done on scorpion, pseudoscorpion, and opilionid populations in central Florida. Rey and McCoy (1983) included pseudoscorpions in their study of spiders in northwest Florida. Muma (1973) did a study on spiders in Winter Haven, but he did not include other arachnids.

Findings on the ground faunas of scorpions, pseudoscorpions, and opilionids in three central Florida plant communities; pond pine, sand pine scrub, and flatwoods are reported. Not only were we interested in species composition and abundance, but also we wanted to determine if seasonal differences exist in the arachnid faunas within a plant community and between the three plant communities.

Study Sites—The study sites were located in the eastern part of the University of Central Florida campus, located approximately 17 km east of Orlando in Orange County (S10 R31E T22S) (Fig. 1).

Plant cover of the pond pine community consisted of trees, shrubs, tree seedlings, grasses, herbs, and vines. Pond pine *(Pinus serotina)* was the dominant tree followed by two bays *(Gordonia lasianthus* and *Magnolia virginiana)*, a holly *(Ilex cassine)*, and black gum *(Nyssa sylvatica)*. Other plants include saw palmetto *(Serenoa repens)*, the grasses *Andropogon* sp. and *Aristida* sp., and fetterbush *(Lyonia lucida)*. The ground surface was covered with a large amount of leaf litter.