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## Effects of Decreased Effluents from Nuclear Fuel Reprocessing on <sup>137</sup>Cs Concentrations in Wildlife

### Abstract

During 1975, additional fiberglass prefilters and HEPA filters were added to the existing air filtering system for atmospheric effluents from the Idaho Chemical Processing Plant (ICPP) on the Idaho National Engineering Laboratory. Pronghorn (*Antilocapra americana*) muscle and liver samples collected near the ICPP prior to filter installation contained Cesium-137 concentrations that were 13 and 18 times, respectively, the concentrations in tissues of control animals. Muscle and liver samples collected after filter installation had only 2.5 times the <sup>137</sup>Cs concentrations in control tissues. The potential committed dose equivalent to man consuming the muscle and liver of a pronghorn from the ICPP vicinity was reduced by a factor of 10 by the addition of the filtering system. Although not statistically significant ( $P > 0.05$ ), <sup>137</sup>Cs concentrations in mourning doves (*Zenaida macroura*) were reduced by a factor of four after the additional effluent filters at ICPP were installed.

### Introduction

The Idaho National Engineering Laboratory (INEL) in southeastern Idaho contains important wildlife habitat. Several species occupying this habitat are popular game animals in Idaho. Up to 6000 of the estimated 20,000 to 23,000 pronghorn (*Antilocapra americana*) in Idaho are on the INEL during winters (Reynolds and Rose 1978). Some pronghorn from as far away as Montana also winter on the INEL (Hoskinson and Tester 1980). Additionally, some pronghorn are present on the INEL throughout the year. Thousands of sage grouse (*Centrocercus urophasianus*) also winter on the INEL (Connelly and Markham 1983). Many of these birds remain on the INEL and breed on the various leks or strutting grounds and subsequently raise their young near the various nuclear facilities. Mourning doves (*Zenaida macroura*) are also numerous during the summer and early fall (Trost *et al.* 1976).

The Idaho Chemical Processing Plant (ICPP) on the INEL reprocesses spent nuclear fuel for the recovery of uranium. During this processing and the solidification of the resultant liquid, trace amounts of radionuclides are released with the atmospheric effluents. As a result of these effluents, tissues of various wildlife species such as mourning doves (Markham and Halford 1982), sage grouse (Connelly and Markham 1983), pronghorn (Markham *et al.* 1979, Markham *et al.* 1980, Markham *et al.* 1982), and raptors (Craig *et al.* 1979) in the vicinity of the ICPP contain higher radionuclide concentrations than do tissues from animals residing off the INEL. Several of these species are hunted adjacent to the INEL and are consumed by sportsmen.

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In 1975 additional fiberglass prefilters and HEPA filters were added to the existing air filtering system at the ICPP to more effectively capture radionuclide particulates discharged with the atmospheric effluents (Nelson 1976). The purposes of this paper are to present the effects of this additional filtering of atmospheric effluents on the radionuclide concentrations in edible tissues of game animals in the ICPP vicinity and to estimate the subsequent potential radiation dose to man consuming tissues of wildlife.

#### Materials and Methods

During September 1972 through December 1976, muscle and liver samples were collected from pronghorn antelope occurring within 10 km of the ICPP and from offsite control animals (Markham *et al.* 1982). Mourning dove muscle samples were collected near ICPP and offsite control areas during the summers of 1974-1977 (Markham and Halford 1982). Control animals were generally collected in the mountain valleys northwest of the INEL, which are not in the predominate northeast-southwest wind patterns. Tissues were analyzed for gamma-emitting radionuclides with a 65-cm<sup>3</sup> germanium-lithium detector and a computer-controlled multichannel analyzer system. All data were log-transformed before statistical analyses in order to use normal distribution statistics. Dose calculation methods have been previously described (Markham and Halford 1982, Markham *et al.* 1982).

During August 1975 an improved filtration system for atmospheric effluents was installed at the ICPP. A separate filtration system previously existed for filtering gases from the nitrogen oxide containing vessel, the nuclear fuel dissolver, and the waste calcining facility which solidifies the resultant liquid after the nuclear fuel is dissolved and the uranium removed. However, all ventilation air from process cells was discharged directly into the atmospheric effluent stack. The new system provided continuous filtration of ventilation air and increased filtration of gasses previously being filtered. Information concerning size, location and other details of the filtering system has been published (Nelson 1976).

#### Results and Discussion

Although pronghorn muscle and liver tissues occasionally contained Cesium-134, Cobalt-60 and Zirconium-95, and mourning dove muscles occasionally contained <sup>134</sup>Cs, <sup>60</sup>Co and Chromium-51, the only radionuclide that was consistently detected in both species was <sup>137</sup>Cs (Markham and Halford 1982, Markham *et al.* 1982). Cesium-137 was detectable in all but one of the muscle and liver tissues of pronghorn collected from both the ICPP and control areas (N = 73). The minimum detectable concentrations in pronghorn muscle and liver was 0.01 pCi/g (pCi = picocurie =  $3.7 \times 10^{-2}$  disintegrations/second). Seventy-eight percent of the mourning doves (N = 20) collected near the ICPP contained detectable concentrations of <sup>137</sup>Cs in muscle tissues. Minimum detectable concentration for <sup>137</sup>Cs in the dove tissues were 0.4 pCi/g in 1974-1975 and 0.6 pCi/g in 1976-1977. However, only 17 percent of the offsite muscle samples (N = 24) contained detectable <sup>137</sup>Cs.

For the period prior to installation of filters, <sup>137</sup>Cs concentrations in both muscle and liver tissues from pronghorn collected near the ICPP were significantly (P < 0.001) higher than concentrations in similar tissues collected offsite (Table 1).

TABLE 1. Cesium-137 in edible tissues of pronghorn antelope and mourning doves before and after installation of additional atmospheric effluent filters at the Idaho Chemical Processing Plant (ICPP).

| Date                         | Sample Size | ICPP<br>$\bar{X} \pm SD$ | Range                   | Sample Size | Control Area<br>$\bar{X} \pm SD$ | Range       |
|------------------------------|-------------|--------------------------|-------------------------|-------------|----------------------------------|-------------|
| Pronghorn Muscle (pCi/g)     |             |                          |                         |             |                                  |             |
| 1972-Aug. 1975               | 14          | 0.57 ± 0.48              | 0.03 - 1.52             | 12          | 0.04 ± 0.02                      | 0.02 - 0.09 |
| Sept. 1975-1976              | 8           | 0.05 ± 0.04              | 0.05 - 0.14             | 5           | 0.02 ± 0.01                      | 0.01 - 0.03 |
| Pronghorn Liver (pCi/g)      |             |                          |                         |             |                                  |             |
| 1972-Aug. 1975               | 12          | 1.04 ± 0.83              | 0.06 ± 1.77             | 10          | 0.06 ± 0.04                      | 0.02 - 0.14 |
| Sept. 1975-1976              | 7           | 0.07 ± 0.08              | BDC <sup>a</sup> - 0.20 | 5           | 0.03 ± 0.01                      | 0.02 - 0.04 |
| Mourning Dove Muscle (pCi/g) |             |                          |                         |             |                                  |             |
| 1974                         | 16          | 3.2 ± 3.6                | BDC - 11.6              | 16          | <0.4 ± 0.1                       | BDC - 0.8   |
| 1976                         | 4           | 2.0 ± 2.2                | 0.7 - 5.3               | 8           | BDC                              | BDC         |

<sup>a</sup>BDC—Below detectable concentration

After August 1975, <sup>137</sup>Cs concentrations in pronghorn muscle tissues from the ICPP remained significantly ( $P < 0.02$ ) higher than concentrations from offsite samples. Although the <sup>137</sup>Cs average concentration in pronghorn liver samples from ICPP during the 1975-1976 sampling period was 2.5 times the average concentration in offsite samples, the difference was not significant ( $P > 0.05$ ).

Cesium-137 concentrations in muscle and liver samples from ICPP pronghorn in the 1972-1975 period were significantly ( $P > 0.001$ ) higher than similar samples collected during the 1975-1976 period. Concentrations in muscle and liver samples from the control area during 1972-1975 were a factor of two higher and were significantly different ( $P < 0.05$ ) from the control samples collected in 1975-1976. Prior to the addition of the new effluent air filtering system, the <sup>137</sup>Cs average concentrations in muscle and liver samples were 13 and 18 times, respectively, the average concentrations in tissues of control animals. After the addition of the filters, the <sup>137</sup>Cs average concentrations in pronghorn muscle and liver from the ICPP were only about 2.5 times that in control animals.

Concentrations in mourning dove muscle tissues collected both before and after the addition of the new filter system were significantly higher ( $P < 0.001$ ) than control tissues. Although the <sup>137</sup>Cs concentrations in the 1974 dove tissues collected near ICPP were almost four times higher than the 1976 ICPP samples, the difference was not significant ( $P > 0.05$ ). Control data for both periods were generally below minimum detectable concentrations.

The total annual <sup>137</sup>Cs emitted into the atmosphere from the ICPP was considerably reduced by the addition of the new air filtering system (Table 2). Subsequent to this study, annual atmospheric releases of <sup>137</sup>Cs from the ICPP for the period 1977-1982 ranged from 0.2 to 0.008 Ci (U.S. Department of Energy 1983).

Big sagebrush (*Artemisia tridentata*) is an important food item for pronghorn on the INEL (Johnson 1979). The primary route of entry of <sup>137</sup>Cs into pronghorn is by ingestion (Markham *et al.* 1982). The biological half-life of Cesium on big sagebrush is approximately 15 days (Millard *et al.* 1983) and the biological

TABLE 2. Annual <sup>137</sup>Cs atmospheric releases from the Idaho Chemical Processing Plant.

| Year                      | <sup>137</sup> Cs Released (Ci) |
|---------------------------|---------------------------------|
| Before Additional Filters |                                 |
| 1972                      | 4.6                             |
| 1973                      | 5.4                             |
| 1974                      | 6.7                             |
| After Additional Filters  |                                 |
| 1975                      | 0.6                             |
| 1976                      | 0.1                             |

half-life for pronghorn is probably similar to the 2-week half-life in other ruminants (Goldman *et al.* 1965, Hokanson and Whicker 1969). Therefore, <sup>137</sup>Cs on the forage and in the tissues of pronghorn probably decreased rapidly when the <sup>137</sup>Cs activity in atmospheric effluents was reduced.

Although <sup>137</sup>Cs concentrations in surface soil likely did not decrease because of its relatively long physical half-life and slow rate of removal, less than 20 percent of the <sup>137</sup>Cs intake by pronghorn was from soil ingestion (W. J. Arthur, unpublished data). The amount of <sup>137</sup>Cs incorporated into the body tissues from this source compared to other sources of consumption is unknown.

If a person consumed the entire muscle mass from a mourning dove equivalent to our sample having the highest concentration of <sup>137</sup>Cs, the potential wholebody committed dose equivalent from the <sup>137</sup>Cs would be 0.02 mrem. Because of the much larger mass of the pronghorn, potential dose equivalents from a person eating the muscle and liver of a pronghorn would be higher. The dose equivalent to man consuming the combined muscle and liver from one pronghorn having the maximum and average concentration of <sup>137</sup>Cs would have been 2.7 and 1.0 mrem, respectively, for the periods prior to the addition of the new filters at ICPP and 0.2 and 0.1 mrem, respectively, for the period after the addition of the filters. The maximum and average committed dose equivalent to man consuming muscle and liver from the control areas during these period prior to filter addition were 0.16 and 0.07 mrem, respectively, and 0.05 and 0.03, mrem, respectively, for the period beginning in September 1975.

The reduction in the <sup>137</sup>Cs concentration in the control pronghorn tissues and the resultant lowering of the potential committed dose equivalent to man is due to decreasing <sup>137</sup>Cs in worldwide fallout. Although there was a small and statistically significant ( $P < 0.05$ ) dose equivalent reduction related to eating a pronghorn from the control areas during the two periods, the much larger reduction in the dose equivalent from eating pronghorn from the ICPP area likely resulted from the additional filter system installed at the ICPP. The radiation doses to both man and pronghorn were well below the doses of 132-134 mrem per year that these organisms receive from natural sources (Markham *et al.* 1982).

#### Acknowledgments

This research was sponsored by the office of Health and Environmental Research, U.S. Department of Energy, Idaho Department of Fish and Game and Federal Aid Project W-160-R.

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This research was sponsored by the office of Health and Environmental Research, U.S. Department of Energy, Idaho Department of Fish and Game and Federal Aid Project W-160-R.

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Received 21 October 1983.

Accepted for publication 20 June 1984.