both *Thais haemostoma* and *Polinices duplicatus* the samples from Galveston are a factor of 1.7 to 2 higher than those from the High Island or Port Isabel areas. The Galveston sample is anomalous for *Busycon* (whelks), although all of the whelks were low in ^{90}Sr compared to the other shells. The fresh water clam (*Cyrtonaias*) was also low in ^{90}Sr as was expected due to the low concentration of ^{90}Sr found in land runoff (Ma56, Li56).

In general, the trend is for a decrease in ^{90}Sr content from the Galveston area southward, Campeche Bay having the lowest.

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#27

^{239}Pu Contamination in Snakes Inhabiting the Rocky Flats Plant Site

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Introduction

INITIALLY plutonium appears not to be a significant environmental hazard due to its low solubility and its few penetrating radiations. Existing knowledge of plutonium cycling in terrestrial ecosystems makes it difficult to answer questions pertaining to the hazards of long-term build-up, availability, transport mechanisms, and inhalation (Wh74). Although radioecological studies investigating the biological availability of plutonium contamination to indigenous species of plants and animals have been reported (Ha72; Ro70; Pa68; Pe64; 0163), insufficient data are available to predict the fate of this element in highly mobile carnivores in a terrestrial environment.

For approx 4 yr studies have been underway at the Energy Research and Development Administration's (ERDA) Rocky Flats plant to determine contamination patterns and concentrations of plutonium in the biota (Wh74). Contamination of the Rocky Flats environs has resulted from at least

three incidents, but leaking barrels containing plutonium-laden cutting oil was considered by far the major source of the plutonium contamination (Kr70). This study was conducted to determine whether snake tissues of the area contained detectable amounts of ^{239}Pu and, if so, at what concentrations.

Materials and Methods

The Rocky Flats installation, located approx 12 km (7.5 miles) north-west of Denver, Colorado, consists of habitat described as relatively undisturbed grassland. The study area covered approx 21 ha and was located in the major windrose immediately downwind from the area previously used for storage of barrels holding plutonium-laden cutting oil. This particular area was selected for the following reasons: reasonably high soil plutonium concentrations (>2000 mCi/km^2), a vegetative community undisturbed for at least 20 yr, continuing work on small mammal (prey) populations, the presence of several snake species, and the accessibility of area.

Eastern yellow-bellied racers (*Coluber constrictor flaviventris*, $n=3$), bullsnakes (*Pituophis melanoleucus sayi*, $n=2$), and prairie rattlesnakes (*Crotalus viridis viridis*, $n=4$) were collected for ^{239}Pu bioassay of three tissues. Snakes were captured using drift fences terminating in funnel traps and by opportunistic sampling. Lung (including trachea), liver, and bone (vertebrae) samples were taken from each of the nine specimens collected at Rocky Flats.

Lungs were selected as a tissue of interest because of their propensity to become contaminated through inhalation of resuspended soil particles containing Pu. Previous work has suggested inhalation to be the principal potential route of entry of Pu into the body (La59). The snake's respiratory apparatus is comprised of a number of parts, the most important of which may be the glottis. This tube projects from the snake's mouth while prey is ingested, enabling the snake to breathe and eat simultaneously. While the snake is feeding, the glottis is in close proximity to the food (e.g. adjacent to pelage of small mammals) increasing the possibility of the snake inhaling ^{239}Pu particles.

Experimental data from mammals suggest that for PuO_2 particles probably about one percent of the originally inhaled amount is absorbed through the lung and into the bloodstream with deposition primarily in bone and liver (Ca47; Ba58; La59; Ba61; Je72). Bone is usually considered the critical organ since it accumulates the majority of Pu and retains it essentially throughout an individual's lifetime (La59; Pe64; Je72). In fact, slower entry of Pu into the bloodstream (e.g. via absorption from the gastrointestinal tract and lungs) may give greater deposition in bone and less in liver (Ca47).

Pu assay was performed by LFE Environmental Analysis Laboratories whose procedure consisted of ashing, total dissolution, electrodeposition, and alpha spectrometry (We75). Minimum detectable activity was 0.04 dpm/sample.

Results

Concentrations (dpm/g) in tissues from the nine snakes collected at Rocky Flats are presented in Table 1. In 20 of 27 tissues sampled the activity was ≤0.1 dpm/g, and in no case did the concentration of any tissue analyzed exceed 1.0 dpm/g. No significant correlations were found between the distance the snake was caught from the presumed source of Pu contamination and the concentrations in the liver ($r<0.01$, d.f. = 7) or bone ($r<0.01$, d.f. = 7).

There was no detectable activity in eight of nine lung samples. Activities in the liver samples ranged from 0.01 to 0.44 dpm/g, while skeletal sample activities ranged from nondetectable (calculated as minimum detectable activity) to 0.56 dpm/g. Liver samples from each of two bullsnakes caught approximately 96 km (60 miles) north of the Rocky Flats site showed no detectable amounts of ^{239}Pu. Although racers appeared to exhibit greater liver and bone concentrations than did either the bullsnakes or the rattlesnakes, a Kruskal–Wallis test showed no statistically significant difference between species with respect to either liver burdens ($T=3.28$; $n=2,3,4$; $\alpha=0.102$) or bone concentrations ($T=1.40$; $n=2,3,4$; $\alpha=0.102$). This particular nonparametric test was performed because of the non-normal distribution suggested by the snake tissue concentrations.

Coefficients of variation (C.V.) of 156 and 176% (i.e. 1.56 and 1.76) were calculated for liver and bone tissues, respectively. This represents some of the lowest variability within biotic components of this study area at Rocky Flats (Wh74).

Discussion

Snakes captured in the Rocky Flats area show detectable concentrations of ^{239}Pu, primarily in the liver and bone tissues. No detectable activity was observed in the majority of the lung samples. Lungs have been considered important in assessing the biological hazards of ^{239}Pu in the environment because of the chance of particle retention and absorption following inhalation (Ro72). The fate of inhaled PuO_2 (probably the predominant chemical form of environmental plutonium) may be affected by any of several variables, the most important of which seems to be particle size. Translocation of

Table 1. Mean ^{239}Pu activities (± S.D.) in tissues of nine snakes collected at Rocky Flats

Species	Tissue (dpm/g) Lung	Liver	Bone	Mean (all tissues)
Eastern yellow-bellied racer (*Coluber constrictor flaviventris*)	<0.07	0.12±0.03	0.01±0.01	<0.07
	<0.11	0.25±0.05	0.34±0.05	<0.23
	<0.15	0.44±0.08	0.56±0.07	<0.38
Mean	<0.11	0.27	0.30	<0.23
Bullsnake (*Pituophis melanoleucus sayi*)	<0.02	0.03±0.02	0.05±0.01	<0.03
	<0.03	0.03±0.02	0.06±0.01	<0.04
Mean	<0.02	0.03	0.05	<0.03
Prairie rattlesnake (*Crotalus viridis viridis*)	0.19±0.09	0.31±0.03	0.05±0.02	<0.18
	<0.05	0.01±0.00	0.05±0.02	<0.03
	<0.02	0.02±0.01	<0.01	<0.02
	<0.07	0.03±0.02	0.03±0.02	<0.04
Mean	<0.08	0.09	<0.04	<0.07
Tissue means (all samples)	<0.07	0.13	<0.13	<0.11

plutonium from lung to other tissues is maximized when aerosols of small mass median diameters (MMDs) are inhaled (Ba62). It is generally believed that when larger Pu particles are deposited, they are effectively cleared from the respiratory tract. A third conceivable explanation of the non-detectable lung burdens may be the small mass of each lung sample. Present analytical procedures generally suggest compositing samples, especially those of low mass, to reduce the possibility of drawing erroneous conclusions (We75). However, a scarcity of snakes restricted the sample size and, therefore, samples were treated individually rather than as a composite in this study.

Absorption of ^{239}Pu through the gut wall into the bloodstream and gradual translocation of $^{239}PuO_2$ from the lungs to other tissues (principally skeleton, muscle, liver and spleen) are two ways that contamination of internal tissues can result, though it is generally believed that the former is not a major route of internal contamination. As previously noted, maximum translocation appears to be particle size dependent, increasing as smaller diameter particles are inhaled and deposited (Ba61; Ba62). Low ^{239}Pu concentrations in the tissues and the lack of any significant correlation between distance from the presumed source of contamination and ^{239}Pu concentrations in the liver or bone may be partly due to the transiency of certain species of snakes (St47; Hi69). Small mammals which are important prey species of snakes, occupy smaller home ranges and exhibit higher tissue concentrations than snakes captured on the same site (T. Winsor, pers. comm.). Conversely, snakes, a very mobile predatory group with broader home ranges, show some of the lowest ^{239}Pu tissue concentrations of any Rocky Flats biota analyzed. Assuming that snakes do not feed exclusively in the more highly contaminated area of Rocky Flats, we would expect to see lower tissue concentrations. Due to the high degree of variability in the data, interpretation of the tissue concentrations is complicated, however the preliminary data suggest that snakes are not an important organism in the redistribution of ^{239}Pu.

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Polonium-210 in Bombay Diet

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Introduction

POLONIUM-210 is a naturally occurring radionuclide in the environment of man. Morgan *et al.* (1964) have, however, included ^{210}Po in the group of most highly toxic radioisotopes. This nuclide is the decay product of ^{210}Pb ($T_{1/2}$ 21.4 yr) and is an alpha emitter with 138 days half-life. Despite its relatively short half-life, it is steadily maintained in the atmosphere due to longer lived precursors. The fate of polonium, in general, is closely linked with its long lived precursors, but sometimes it has been observed in nature independently and at substantially higher levels (Fo72). It is present in atmosphere because of natural fallout from radon disintegration products escaping into the atmosphere from soil. Natural fallout and rainout are important sources of ^{210}Po in food which is one of the important routes of entry into the body. In the case of smokers, additional intake of ^{210}Po is to be expected from cigarette smoke.

Assessment of ^{210}Po concentrations in different food stuffs is essential for estimating the intake of ^{210}Po from foods by man. This note gives the concentration levels of ^{210}Po in most of the common foods in the typical Bombay diet and provides estimates of the total daily intake of ^{210}Po by an individual of Bombay city.

Experimental

Sample collection and analysis

Samples selected for analysis were common foods in the Bombay city diet according to the data provided by the *Diet Atlas of India* (1964). Table 1 gives the quantitative information about the major food items constituting average daily diet of Bombay population. The samples were procured (mostly between 1 and 2 kg) from Bombay city and suburban areas and were wet ashed using nitric acid and hydrogen peroxide. In the final stage, nitric acid was removed from the sample solution by evaporating it with hydrochloric acid. The residue was then dissolved in 150 ml of 0.5 M hydrochloric acid, 0.5 g of hydroxylamine hydrochloride was then added and the solution was transferred into plating cell which was placed in water bath at 90°C.