Strontium-90 in Ecuador

Abstract. Samples of bone and soil collected in 1958 show highest values for Sr^{90} in the tropical region on the east side of the Andes. Lowest values are found in the high central valley, where samples used in estimating world-wide distribution of fallout were collected. If the major fallout deposition occurs in the interior of the South American continent, such estimates for these latitudes may be low by as much as a factor of ten. Although there has apparently been greater Sr^{90} deposition in regions of greater rainfall, analysis of data from 16 locations fails to show a significant correlation between rainfall and fallout.

From January through May in 1958, 45 samples of soil and bones from 19 cattle were collected along the equator in Ecuador, from the Pacific coast to the tropical regions on the eastern side of the Andes, including points up to 13,500 feet above sea level, in the mountains. These samples were analyzed for Sr^{90} content in the laboratories of the Analysis Branch, Idaho Operations Office of the U.S. Atomic Energy Commission (*1*).

Ecuador provides unusual extremes in altitude, and hence in climatic conditions, in a very short linear distance. From the coast to a distance of approximately 100 miles inland, one passes through tropical, subtropical, temperate, and páramo (tundra) zones. In a comparable distance east from the high mountains, one again descends to regions of the tropical rain forest. These climatic changes are manifestations of differences in both temperature and precipitation, and both are reflections of the topography. The mountain chain is divided roughly into two rows of high peaks with a broad temperate valley between. The climate of the valley is temperate because of its elevation, which averages about 9000 feet above sea level. It is an arid region, most of the moisture being excluded by the higher mountains to the east and west. Nearly all of the major cities, the majority of the population, and the most extensive agricultural areas are located in this valley.

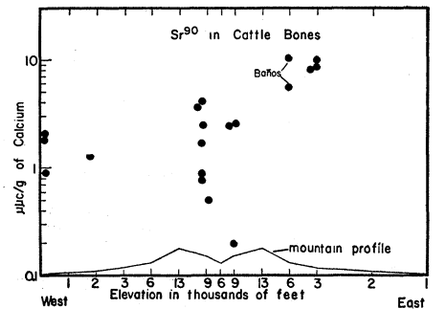

Fig. 1. Strontium-90 in cattle bones from Ecuador.

Figure 1 shows Sr^{90} content of cattle bones, expressed as micromicrocuries per gram of calcium, and plotted against location along an east-west transect across the country. The transect is indicated on the abscissa by changing elevation with distance (not to scale). A diagram of the mountain profile, according to the scale of the abscissa, has been added for aid in comparing relative positions of the sample locations. Figure 2 presents the results of soil samples, with Sr^{90} content expressed in millicuries per square mile.

The Sr^{90} levels are distinctly highest at the lower elevations to the east. Due to difficulties of transportation in the country, the cattle parts may be considered of local origin, with some possible exceptions in the highlands. Bone samples from five species of native animals, not shown in the figures, were collected in the tropics of the eastern slope. These samples and their Sr^{90} values in micromicrocuries per gram of Ca were: white-lipped peccary (*Tagassu pecari*), 3; collared peccary (*Tagassu tajacu*), 2; three-toed sloth (*Bradypus*), 10; wild dog (*Atelocynus microtus*), 5; and a deer (*Cervidae*), 2. A kinkajou (*Potos*) from 700 feet elevation near the west coast had 2 $\mu\mu$c/gm of Ca.

Soil levels of Sr^{90} were lowest along the arid strip of coast, arid because of cold oceanic currents, and the interior regions of the high central valley, also an area of little rainfall. The lowest point toward the eastern base of the mountains in Fig. 2 represents an unusually arid area for that region, the town of Baños which is hemmed in by high ridges. Two samples of cattle bones from Baños were comparatively high in Sr^{90}. This discrepancy cannot be explained by soil calcium values. Indeed, these data show no relationship between soil Ca and either soil Sr^{90} or bone Sr^{90}. If there is a correlation between Sr^{90} deposition and rainfall, then perhaps the Baños cattle are high in this isotope because they grazed in adjacent areas of greater rainfall and more lush vegetation rather than in the semiarid area around the town.

Soil levels of Sr^{90}, being higher in the humid tropical regions and at high elevations, seem to substantiate a direct correlation between fallout deposition and rainfall. Data for 16 locations from which values for both annual precipitation (average for 3 to 5 years) and Sr^{90} in soil are available (Table 1) were analyzed for linear regression. The result was not significant ($P > 0.3$), indicating that these data fail to show a correlation between rainfall and Sr^{90} in soil.

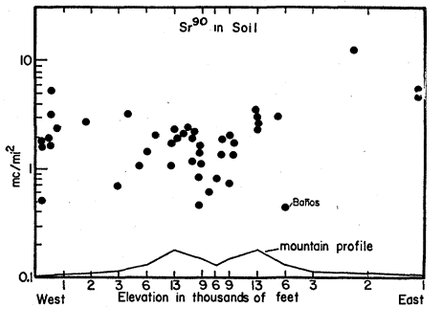

Fig. 2. Strontium-90 in soil from Ecuador.

There was some concern that soil samples taken near the end of the collecting period might be significantly higher in activity because of fresh fallout moving in at that time from the 1958 nuclear tests being conducted at the Pacific Proving Grounds. Thyroid glands of both cattle and sheep collected in Quito and analyzed for I^{131} content by L. Van Middlesworth of the University of Tennessee increased by factors of 100 or more between early and late May. Additional data timing the arrival of the fallout in the vicinity was obtained by the detection of W^{185} (*2*). Comparison of soil samples taken before and after arrival of fallout shows no greater variation than that shown by other samples not influenced by this variable.

It is important to note that the valley between the high peaks is a region of particularly low Sr^{90} deposition. Samples used for estimating world-wide distribution of fallout (*3*) have apparently been collected in such locations, because here are the population centers or commercial centers, and samples are frequently collected near

Table 1. Comparison of average annual precipitation and Sr^{90} content of soil. Linear regression analysis was not significant ($p > 0.3$).

Locality	Precipitation (mm)	Sr^{90} (mc/mi²)
Coast		
Manta	243	1.8
Esmeraldas	822	1.6
San Lorenzo	2797	1.6
Western tropical region		
Quevedo	2484	5.4
Santo Domingo	4018	2.7
Central valley		
Aloag	940	1.6
Quito	1364	1.4
Calderón	960	0.6
Guaillabamba	565	1.4
Tabacundo	876	1.7
Otovalo	1029	2.1
Ibarra	743	1.9
Latacunga	272	1.4
Ambato	472	0.7
Eastern subtropical region		
Baños	1249	0.5
Eastern tropical region		
Puyo	3871	12.6

government agencies, airports, and other facilities. Such samples may provide estimates of Sr^{90} deposition that are low by a factor of 2 to 10, compared with the deposition in adjacent areas.

The highest values for Sr^{90} in these samples consistently come from the tropical zone at the eastern base of the mountains. This suggests, since the moisture moves into that region from the east across the entire continent, that a greater portion of the fallout moves from east to west in this part of the southern hemisphere. This is consistent with general global circulation patterns for these latitudes. Perhaps the major portion of the fallout on the South American continent may be found in the interior tropical regions, although the path of circulation from the point of origin is obscure.

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References and Notes

1. Samples were collected under sponsorship of the Division of Biology and Medicine of the U.S. Atomic Energy Commission and the National Science Foundation. G. W. Prescott and R. W. Hodges aided in collection of samples. E. R. Ebersole, P. B. LeFleur, and W. C. Pierce carried out chemical analyses. The method of analysis was essentially the soil leach procedure described in *NYO-4700* (1957).
2. L. B. Lockhart, Jr., R. A. Baus, R. L. Patterson, Jr., A. W. Saunders, Jr., *Science* **130**, 161 (1959).
3. E. A. Martell, *Science* **129**, 1197 (1959); M. Eisenbud, *Science* **130**, 76 (1959); *Health and Safety Laboratory, U.S. Atomic Energy Commission, HASL-42* (1958).

31 March 1960

Decarboxylase Inhibition and Blood Pressure Reduction by α-Methyl-3,4-Dihydroxy-DL-phenylalanine

Abstract. α-Methyl-3,4-dihydroxy-DL-phenylalanine has been found to be an effective inhibitor of aromatic amino acid decarboxylation in man. This was shown by decreased formation of serotonin, tryptamine, and tyramine from the precursor amino acids. Reduction of amine biosynthesis is associated with lowering of blood pressure in hypertensive patients and a transient sedative effect.

The aromatic amines impinge on almost every area of biological and medical interest. Two basic approaches to the study of amine metabolism, which have had interesting and practical implications in man, are depletion of tissue stores of amines by the rauwolfia alkaloids and inhibition of the degradation of amines by monoamine oxidase inhibitors. Since decarboxylation of an amino acid is a requisite reaction in the biosynthesis of aromatic amines, decarboxylase inhibition seemed to offer a third biochemical approach in this area and one which had not been explored previously in clinical studies.

Table 1. Inhibition of the decarboxylation of three amino acids by α-methyl-dopa. Values represent micrograms of amine excreted in the urine during an 8-hour period. For tyramine and tryptamine they represent the average of two experiments and for serotonin an individual experiment.

Patient	Urinary serotonin (after infusion of 30 mg of 5-hydroxy-DL-tryptophan)		Urinary tyramine (after L-tyrosine 125 mg/kg orally)		Urinary tryptamine (after L-tryptophan 50 mg/kg orally)	
	Control	α-methyl-dopa	Control	α-methyl-dopa	Control	α-methyl-dopa
V.K.			968	262	373	180
R.E.	3086	1347	1090	155	503	200
E.C.	2423	649	422	78	52	31
J.W.	2806	1086	750	124	56	30
H.F.	3570	1315				

A number of compounds are known to inhibit decarboxylation in experimental animals (*1, 2*). Of these α-methyl-3,4-dihydroxy-DL-phenylalanine (α-methyl-dopa) was selected for possible administration to humans. This compound, synthesized by Stein, Bronner, and Pfister (*3*), was first shown to be an effective inhibitor of dihydroxyphenylalanine decarboxylation in vitro by Sourkes in 1953 (*1*), an effect which was subsequently confirmed pharmacologically (*4*). Inhibition of 5-hydroxytryptophan decarboxylation was also demonstrated (*5*), and a decrease in brain serotonin levels was observed after parenteral administration of this inhibitor to mice (*6*).

Techniques for the measurement of amino acid decarboxylation in man have been developed recently in this laboratory. Preparatory to clinical investigations of α-methyl-dopa, chronic toxicity studies were performed by the Merck Sharp & Dohme Laboratories, and the compound was found to have a wide range of safety. α-Methyl-dopa was then administered to hypertensive patients at the Clinical Center. It was found to be a highly effective inhibitor of aromatic amino acid decarboxylation in man and to have hypotensive and sedative properties.

The decarboxylation of 5-hydroxytryptophan, tyrosine, and tryptophan was investigated by measuring the urinary excretion of their respective amines (serotonin, tyramine, and tryptamine) after administration of the precursor amino acid. L-Tryptophan and L-tyrosine were administered orally and 5-hydroxy-DL-tryptophan was given intravenously over a period of 90 minutes. Starting with administration of the amino acid, urines were collected for a period of 8 hours. During this time, the patients received a diet low and constant in tryptophan and tyrosine. When all control studies were completed, single 2.0-gm doses of α-methyl-dopa were administered daily. After at least 2 days of treatment with the inhibitor, the individual amino acids were administered again and urine was collected as before. In each case, the amino acid was given 2 hours after the last dose of α-methyl-dopa. Urinary serotonin was isolated from small aliquots of urine on an IRC-50 (NH_4+) column, eluted with 1*N* HCl, and assayed fluorimetrically (*7*). Tryptamine (*8*) and tyramine (*9*) were assayed by methods developed previously in this laboratory.

As shown in Table 1, amine formation after administration of all three amino acids was decreased by α-methyl-dopa, the decreases averaging 63 percent for 5-hydroxytryptophan, 80 percent for tyrosine, and 50 percent for tryptophan. α-Methyl-dopa also reduced the excretion of tyramine 50 to 85 percent in comparable 8-hour periods during which loading with tyrosine was omitted. The possibility existed that the effect of α-methyl-dopa on the excretion of amines might be due to

Table 2. Reduction of blood pressure by α-methyl-dopa.

Patient	Dose (gm/day)	Average blood pressures (mm-Hg)				Change	
		Control (placebo) week		Final week of drug		Lying	Standing
		Lying	Standing	Lying	Standing		
V.K.	2.0	159/93	168/102	135/79	122/82	−24/−14	−46/−20
F.J.	1.5 –2.0	173/94	169/104	136/82	116/81	−37/−12	−53/−23
F.N.	0.75–2.0	244/140	220/146	229/147	171/117	−15/+7	−49/−29
R.E.	1.0 –2.0	140/97	142/107	119/80	120/90	−21/−17	−22/−17
H.C.	1.5 –2.5	202/128	177/130	196/127	142/113	−6/−1	−35/−17
J.M.	2.0 –4.0	208/122	191/123	212/143	144/107	+4/+21	−47/−36
E.C.	2.0 –3.0	155/98	150/104	133/79	109/78	−22/−19	−41/−26
E.B.	2.0 –3.25	208/126	196/125	227/121	170/109	+19/−5	−26/−16
H.J.	2.0 –2.5	154/114	144/111	147/110	122/89	−7/−4	−22/−22
R.P.	3.0 –6.0	227/142	220/141	200/113	170/114	−27/−29	−50/−27