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QUARTERLY RESEARCH REPORT TO THE NASA MANNED SPACECRAFT CENTER

THE MEASUREMENT OF RADIATION EXPOSURE OF
ASTRONAUTS BY RADIOCHEMICAL TECHNIQUES

January 1, 1973 through April 1, 1973

by

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April 15, 1973

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TABLE OF CONTENTS

	Page No.
List of Tables	iii
Abstract	1
Determination of the Radionuclide Content of Feces and Urine from Astronauts Engaged in Space Flight	2
Neutron Activation Analysis of Feces and Urine from Astronauts Engaged in Space Flight	5
Expenditures	6
References	8
Distribution	9

LIST OF TABLES

		Page No.
Table I	Radioactivity in Urine from Apollo 17 Astronauts	3
Table II	Expenditures	7

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ABSTRACT

A cosmic radiation dose to the Apollo 17 crew of $\leq$ 210 mR was calculated from the concentrations of ^{24}Na in their postflight urine specimens. The complete absence of measurable quantities of ^{22}Na indicates the radiation doses were among the lowest ever received on a mission of this duration. The levels of ^{42}K administered by post-flight injection are also reported for these samples. Antimony-124 and iridium-192 were observed for the first time in urine specimens. The excretion of these radioisotopes and of ^{60}Co correlated well with that of ^{51}Cr ; they are shown to be impurities in the radiochromium tracer present at levels as high as 4.4% at the time of injection. The ^{40}K , ^{59}Fe , and ^{137}Cs concentrations are also reported and appear to be normal.

The urine specimens from the Apollo 17 mission astronauts have been neutron activated and are currently being analyzed to determine their elemental concentrations.

THE MEASUREMENT OF RADIATION EXPOSURE OF
ASTRONAUTS BY RADIOCHEMICAL TECHNIQUES

Determination of the Radionuclide Content of Feces
and Urine from Astronauts Engaged in Space Flight

Astronauts engaged in space flight are subjected to cosmic radiation which induces radioactive isotopes in their bodies. The radiation dose received from cosmic particles can be determined from the quantities of these induced radionuclides.⁽¹⁾ The concentrations of these induced activities can be ascertained by direct whole-body counting of the astronauts or by indirect measurement such as counting that fraction of the radionuclides excreted in feces and urine. The latter approach has been used on all manned Apollo missions. In addition to the induced activities, several fallout, injected, or naturally occurring radioisotopes have been measured; variations in their concentrations may be indicative of changes in the biological life processes encountered in the space environment.

The concentrations of the radioisotopes listed in Table I have been normalized by dividing each decay-corrected disintegration rate by the volume of urine. All samples were handled according to procedures described earlier.⁽¹⁾ A cosmic radiation dose to the Apollo 17 crew of ≤ 210 mR was calculated by comparing the postflight ^{24}Na concentrations in their urine to those in the urine of radiotherapy patients.⁽²⁾ This value is relatively uncertain, however, due to the possibility of injection of small amounts of ^{24}Na along with the relatively large amounts of ^{42}K normally administered postflight. An aliquot of the ^{42}K injection was not obtainable for analysis,

TABLE I
RADIOACTIVITY IN URINE FROM APOLLO 17 ASTRONAUTS

dis/min/ml on December 29, 1972 at 1100 PST										
Astronaut	Flight Period	^{24}Na	^{40}K	^{42}K	^{51}Cr	^{59}Fe	^{60}Co	^{124}Sb	^{137}Cs	^{192}Ir
CDR	F-30		1.968 ± 0.059					0.0529 ± 0.0039	0.0455 ± 0.0073	0.0024 ± 0.0012
CMP	F-30		1.981 ± 0.066		0.36 ± 0.12		0.0028 ± 0.0011	0.013 ± 0.003	0.0725 ± 0.0081	
LMP	F-30		2.853 ± 0.057		7.99 ± 0.14	0.107 ± 0.013			0.0527 ± 0.0067	
CDR	F-15		4.212 ± 0.082		1441 ± 10			0.017 ± 0.004	0.0142 ± 0.0095	0.1319 ± 0.0037
CMP	F-15		1.59 ± 0.11		853.4 ± 0.7				0.030 ± 0.013	0.0187 ± 0.0024
LMP	F-15		2.609 ± 0.069		1368 ± 24	0.014 ± 0.013		0.0042 ± 0.0023	0.0394 ± 0.0083	0.0748 ± 0.0026
CDR	F-5		2.53 ± 0.25		159.0 ± 0.7		0.0035 ± 0.0013		0.095 ± 0.032	
CMP	F-5		3.013 ± 0.078		86.55 ± 0.29	0.095 ± 0.017			0.0673 ± 0.0094	
LMP	F-5		3.451 ± 0.071		85.76 ± 0.21			0.0053 ± 0.0023	0.0402 ± 0.0082	
CDR	R+O	<0.20	1.053 ± 0.047	1170 ± 7	2265 ± 7		0.0714 ± 0.0025	0.0460 ± 0.0041	0.0424 ± 0.0062	1.475 ± 0.010
CMP	R+O	<0.29	0.497 ± 0.062	885.0 ± 6.9	1224 ± 6		0.1246 ± 0.0038	0.022 ± 0.004	0.0184 ± 0.0080	0.4751 ± 0.0066
LMP	R+O	<0.82	2.47 ± 0.10	4491 ± 16	5878 ± 16		0.678 ± 0.011	0.127 ± 0.010	0.116 ± 0.014	3.366 ± 0.022

although some ^{24}Na could reasonably be expected to be present in such a reactor-produced tracer. The complete absence of any ^{22}Na activity in the urine indicates the radiation doses were low -- possibly among the lowest ever received on a mission of this duration.

The ^{51}Cr concentrations listed in Table I indicate injections of this radiotracer were administered between 15 and 30 days prior to flight and immediately after splashdown. Analysis of aliquots of the radiochromium tracers after the mission confirmed the presence of the reported radioisotopes, ^{60}Co , ^{124}Sb , and ^{192}Ir as contaminants. It is interesting to note that the urinary excretion of injected iridium almost exactly correlates with that of injected chromium; whereas, cobalt and antimony demonstrate more independent excretion patterns. Although radiochromium was administered in earlier missions, the radioisotopes ^{124}Sb and ^{192}Ir were not present in the urine specimens; hence, the source of ^{51}Cr must have been different for the Apollo 17 mission. Radioisotopic contamination of the chromium spike was as high as 4.4% at the time of injection.

The postflight ^{42}K concentrations reflect the injection of this radiotracer, and the concentrations of ^{59}Fe , ^{137}Cs , and ^{40}K are all at normally expected levels. The ^{40}K data demonstrate the well-characterized postflight retention of potassium.

Neutron Activation Analysis of Feces and Urine
from Astronauts Engaged in Space Flight

This program was initiated in an attempt to foresee any possible metabolic changes in astronauts caused by conditions of weightlessness and prolonged physical inactivity which might have been manifested by an uptake or loss of an element or elements by their bodies. The primary concern had been the terrestrially observed phenomenon of osteoporosis (loss of skeletal calcium); although changes in the uptake and excretion rates of other essential microconstituents of the body, such as Co, Fe, Se, and the alkali metals, were also important.

The urine specimens from the Apollo 17 mission have been neutron activated. Analysis of the short-lived induced activities has been completed, and the samples are presently being analyzed for their long-lived induced radioisotopes. The results will be presented in a later report after all data have been collected and evaluated.

EXPENDITURES

Table II lists the expenditures according to task and total cost incurred from January 1, 1973 through April 1, 1973.

TABLE II
EXPENDITURES

Task	Expenditures
Determination of the radionuclide content of feces and urine from astronauts engaged in space flight	\$4380
Neutron activation analysis of feces and urine from astronauts engaged in space flight	<u>1627</u>
Total Costs	\$6007

REFERENCES

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