

## STUDIES OF THE RETAINED $^{137}\text{CS}$ AND $^{40}\text{K}$ IN INDIVIDUALS

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### ABSTRACT

*Caesium-137 and Potassium-40 activity in Egyptian individuals of nuclear research center are monthly scanned during a period of two years using the whole body counting technique. The results show a slight continuous increase of the body burden radio-element activities. The net daily intaked caesium and potassium are calculated using a developed formula from that of ICRP. The results for K show a variation ranged from 30 - 50 Bq for females and 45 - 65 Bq for male, where for Cs show slight variation ranged from 5.2 - 6.8 Bq for both composite sex. The authors re-emphasized the importance of the periodic measurement of human population.*

### INTRODUCTION

Caesium is one of the radionuclide that are of public health importance because of its presence in fallout as well as its relatively long life (Lewis 1976). Furthermore, the major source of caesium body burden is through the path way chain of food varieties (may be contained radio caesium and / or natural radio potassium) which daily feeded by human being in different organs (Feige 1974, Fujita 1966, Moore 1969). Rundo *et al.* (1964) has found a remarkable similarity between the distribution of K and Cs in the muscles of humans. Since Cs and K are both 100 % well absorbed from the diet in soft tissues (muscle) of the body (ICRP

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1977), this is because both radioelement have chemical similarity (Gustafson 1969), both metabolized by the same biological system and both are measurable simultaneously. Hence forth, Rundo (1964) and Gustafson (1969) are also reported that Cs content in the body can be expressed in term of K. Generally, retention of Cs in body can be approximated closely by two exponential compartment model (ICRP 1977, Gustafson 1969, ICRP 1979). The retained order of Cs is a factor dependance on its effective half life which is a parameter of Cs physical and biological half life. Moreover both Cs and K show a physiological similarity (Leggett 1986). Since the net retained daily intaked Cs and K in known subjects is rather more than interesting point of view, we have been determined in the present article the Caesium-137 body burden and naturally presented potassium-40 content in some specified occupational users of the Egyptian Nuclear Research Center (N.R.C.). The results have been monthly achieved for a period of more than two years.

### **EXPERIMENTAL PROCEDURE**

Scanning of Cs and K contents in healthy addults of 10 male and 8 female subjects of the Egyptian Nuclear Research Center have been studied over a period of two years, using the chair geometry whole body counting system. The adult subjects being under whole body counting are selected for age (32 - 50 years), and for male body weight (60 - 75 kg), hights (165 - 185 cm) as well as for female body weight (48 - 65 kg) and hights (148 - 165 cm). The whole body counter was calibrated for measurements of Cs and K using a construction phantom assembly fitted the reference man size. For reference standard man size the calibration sensitivity of the whole body counter was determined by distributing a point source

inside the committed standard hard board constructed sheets phantom. While for K, polyethylen bottles are used to fit the committed standard phantom size (abdel-Wahab 1992). In order to insure a reasonable counting sensitivity for each subject, the counting time was selected to be 1 hr. The experimentally predicted whole body counting were corrected for the effect of background in the interested region of K and Cs as well as the contribution effects of K on the region of interest for Cs. The systematic errors involved in the measured activity of body burden K and Cs due to the measuring system are found to be due to : (a) Calibration reproducibil accuracy, (b) Electronic stability and (c) The statistical errors, which was found to be  $\pm 10 - 15 \%$ .

## RESULTS AND DISCUSSION

Figures 1 and 2 display the individual retained amount of K and Cs during the scanning time course of the whole body counter respectively. The results shows significant reduction in retained K and Cs body burden activity in females when compared with that of males. This changes can be attributed to the reduced female body size, effective half life of Cs and K as well as their rate of transfere to the different organs (ICRP 1977). Potassium body burden activity in male subjects ( $\text{gm} / 1000 \text{cm}^3$ ) which is selected as a fraction of the total index volume, presented the body organs started from chest down to the knees, exhibited an increase during the time coures of whole body scanning as indicated in figure 1. The initial predicted average of body burden K for 10 male subjects was found to be about  $4.38 \pm 0.86 \text{ g} / 1000\text{cm}^3$ . Further, the experimentally predicted accumulated activity of total body K after the end of the two years whole body scanning time cours, has been found to be about  $4.9 \text{ g} / 1000 \text{cm}^3$ . Furthermore, the characteristic behaviour of the scanned

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total body K for female showed a remarkable changes behaviour than that for male. The results for female showed a step build up rise in total body K during the first 12 months, followed by a remarkable decrease which preceeded a stabilization-increasing region in activity during the second year. Even according to data of figure 2, the trends of the Cs content against time course presented a different behaviour for similar sex group. This may be attributed to, (a) the variation of the radiocaesium-levels incorporated between the intracellular of the daily intaked food meals, (b) the change of the muscles and flesh meat to bone ratio from subject to subject since Cs is mainly presented in muscles. These changes may be due to the variation in the effective half life of body burden radiocaesium in different subjects (Lipsztein 1991). In addition to the transefered fractions of radiocaesium to human being organs during the pathway chain of the feeded food by different subject, beside the excretion rate of the intaked Cs content in food. In brief, the scanned Cs and K in body burden in individuals are subjected to build up increase and decrease from month to month. Using the scanned Cs and K results, monthly measured in the individual, the predated values of daily net retained K and Cs activity ( $P_t$ ) in individuals of 10 males and 8 females were calculated using a simple modified formula developed from ICRP (1979) according to the equation

$$\frac{dq(t)}{dt} = P(t) - \frac{0.693}{T_{eff.}} q(t) \quad 1$$

assuming that the daily intaked radioelement in the food by subjects are of equal activity (Leggett 1986, ICRP 1979).

Where :  $T_{eff}$  = effective half life of Cs and K of respective values of 80 and 75 days (ICRP 1977) and  $q(t)$  represent the monthly measured whole body burden.

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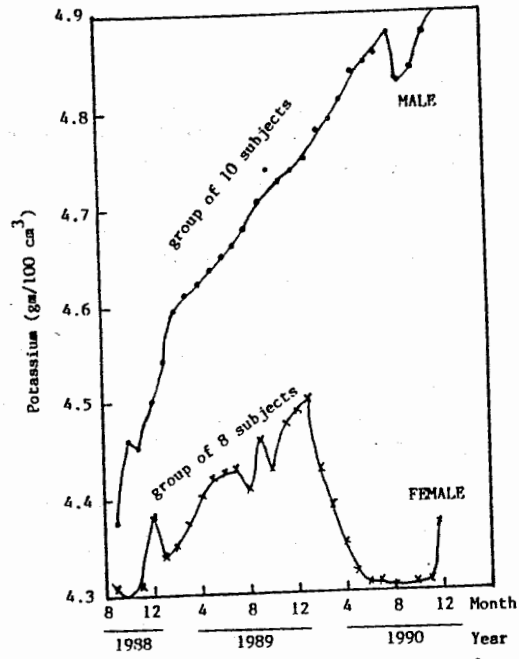


Fig. (1) : Time course of K content in individuals.

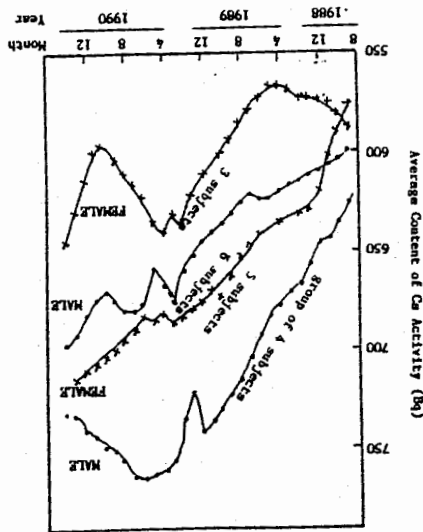


Fig. (2) : Time course of Cs content in individuals.

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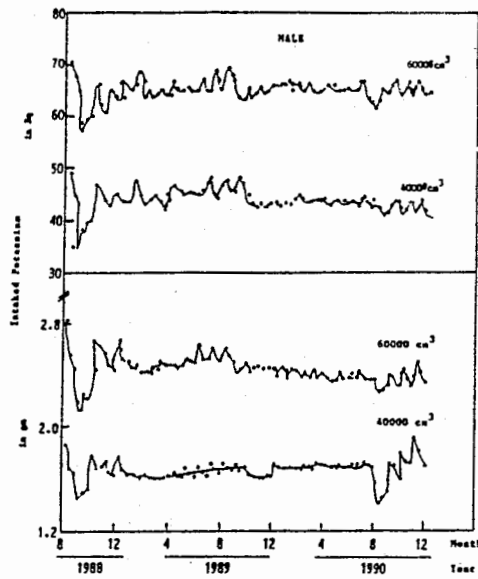


Fig. (3) : Time course of net daily retained activity of intaked K in male individuals of different index volume.

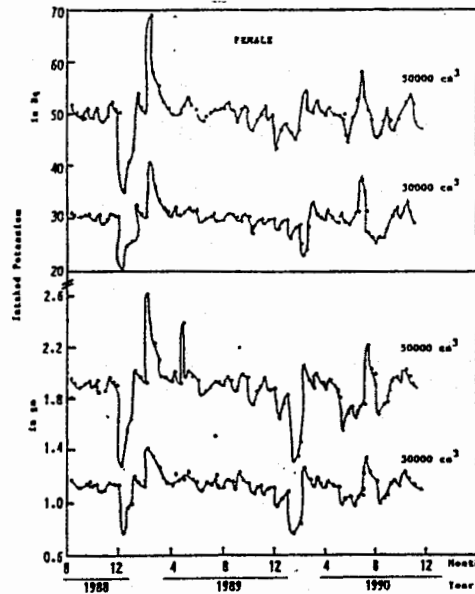


Fig. (4) : Time course of net daily retained activity of intaked K in female individuals of different index volume.

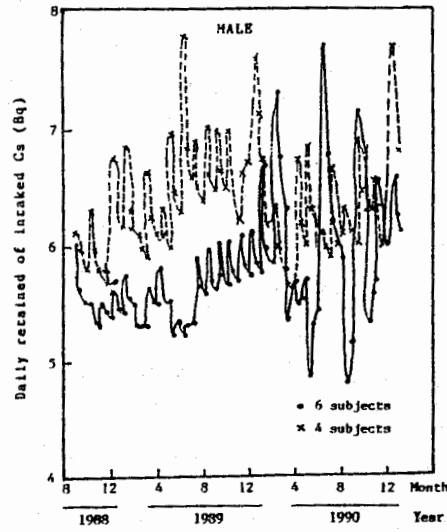


Fig. (5) : Time course of net daily retained activity of intaked Cs in male individual subjects of different index volume.

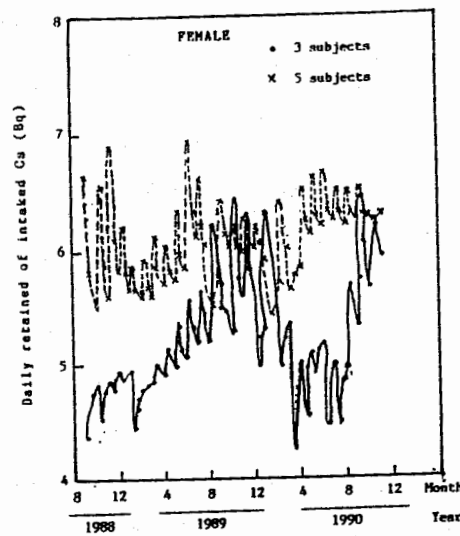


Fig. (6) : Time course of net daily retained activity of intaked Cs in female individual subjects of different index volume.

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If P is constant between two successive whole body burden measurement carried out at interval of t days, the solution of equation (1) can be represented by the following formula.

$$q_t = 1.44 T_{\text{eff}} P(1 - e^{-(0.693 / T_{\text{eff}})t}) + q_0 e^{-(0.693 / T_{\text{eff}})t} \quad (2)$$

where  $q_0$  : body burden of K and Cs in any month, and  $q_t$  that of subsequent month.

The predicted results for P estimated according to eq. (2) are graphically presented in figures 3, 4, 5 and 6. The daily retained activity of Cs and K in both composite sex are classified into two groups according to the geometric size fitted the subjects of each group. However, the present results for K shows a variation ranged from 30 to 50 Bq for female and 45 to 65 Bq for male. Meanwhile the daily retained Cs shows a slight variation ranged from 5.2 to 6.8 Bq for both composite sex. Furthermore, the statistically fluctuated data of the daily intaked Cs and K are shown in table 1.

Table (1) : Statistically fluctuated daily retained activity of Cs and K intaked.

Sex	Group No.	Individuals	retained activity	
			K in gm / 1000 cc	Cs in Bq
Male	1	4	$3.7 \times 10^{-5}$ - $4.8 \times 10^{-5}$	6.05 - 7.40
	2	6	$3.8 \times 10^{-5}$ - $4.76 \times 10^{-5}$	5.15 - 7.45
Female	1	3	$4.0 \times 10^{-5}$ - $4.7 \times 10^{-5}$	4.17 - 6.22
	2	5	$4.0 \times 10^{-5}$ - $4.67 \times 10^{-5}$	5.25 - 6.45



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On commencing the present study, the authors devoted their attention to the proper selection of the subjects with special notice on age, sex and geometry dimensions of the body size fitted the subjects. Each daily retained activity of Cs and K in humans is subjected to decayed out by a factor dependance on the radioelement effective half life. Data of figures (1, 2) show a gradually increase in the body burden of K and Cs in subjects. This ascent are not of well known reason. This would be an interesting point of view in near future to asses the relation between that increased rate of body burden K and Cs and dietary intaked of Cs and K in path way of food. Also, it has been difficult to conclude that change is attributed to any relevent changes in fallout levels especially for Cs, because the fallout levels during the last two years does not show significant variation. In brief it can be predicted that the rate of daily intaked activity of K and Cs are approximately constant, the slight statistical fluctuation in the intaked Cs and K activity may be attributed to the experimental errors.

Tht authors believe that assessment of radioactive body burden in humans should be performed periodically even through that expected low level.

### REFERENCES

- Abdel-Wahab M. S., Youssef S. K., Aly A. M. and Magda T. A. (1992), Potassium body burdens in occupational users of Egyptian Nuclear Research Center, Accepted for publication in applied radiation and isotopes (U.S.A.).
- Anderson E. C. (1958) : Radioactive of people and milk, Sci. 128, 882.
- Booker D. V. (1959) : Caesium-137 in dried milk, Nature 183 - 921.
- Fujita M., Iwamoto J. and Kondo M. (1966) : Comparative metabolism of Cs and K in mammals-interspecies correlation between body weight and equilibrium level, H. P. 12 - 1237.

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Fujita M., Yabe A., Akaishi J. and Ohtani S. (1966) : Relation between ingestion, Excretion and accumulation of fallout caesium-137 in man on a long time scale, H. P. 12 - 1649.

Feige Y., Eisenberg A., Prodlov Y. and Klopper J. (1974) : Long lived radionuclides in food; <sup>90</sup>Sr, <sup>137</sup>Cs in Israel Diet, in comparative studies of food and environmental contaminations IAEA 271.

International commission on Radiological Protection (1979) : Limits for intakes of radionuclides by workers. Oxford : Pergamon Press ICRP 30

International Commission on Radiological Protection, Oxford : Pergamon Press ICRP 26.

Gustafson P.F. and Miller J. E. (1969) : The significance of <sup>137</sup>Cs in man and his diets, H. P. 16 - 167.

Leggett R. W. (1986) : Predicting the retention of Cs in individuals, H.P. 50 - 747.

Lewis J. T., Kereiakes J. G. (1976) : Caesium - 137 body burdens and half life in a group of adult males in Cincinnati, Ohio, H. P. 30 - 315.

Lipsztein J. L., Bertelli L., Oliveira C. A. N. and Dantas B. M. (1991) : Studies of Cs retention in the human body related to body parameters and prussian blue administration, H. P. 60 - 57.

Moore W. and Comare C. L. (1969) : Int. I. Radiat. Biol. S. 24.

Rundo J. and Taylor T. (1964) : Assessment of radioactivity in man, vol. II, IAEA - 3.