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EVALUATION OF THE SAMPLE ROTATION METHOD FOR THE MEASUREMENT OF GAMMA ACTIVITY IN LARGE INHOMOGENOUS SAMPLES OF BIOLOGICAL MATERIAL

MAGDA HARMUT, I. ŠIMONOVIĆ, S. POPOVIĆ, V. JOVANOVIĆ

Institute for Medical Research and Occupational Health, and Medical Faculty, Zagreb University, Zagreb

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The sample rotation method was evaluated with an instrument partly constructed at the Institute for Medical Research and Occupational Health. The purpose of our investigation was to find the optimal compromise between the sensitivity of the instrument and the measuring error due to the inhomogeneity of the sample. The method was evaluated with ^{85}Sr and ^{47}Ca. On the basis of our experimental data we conclude that for the determination of radioactivity in large samples of biological material a relatively modest instrument accessible to all clinical radioisotope operating institutions can be used.

In metabolic radioisotope studies there is need for a simple and inexpensive system for the determination of gamma activity in large samples of biological material.

A method for the direct determination of radioactivity using a crystal scintillation detector was first described by *McKenna* (1). For direct measurements both liquid and plastic scintillation detectors have also been used (2, 4, 5, 6). Systems in which the sample is rotated in front of a fixed detector have been described by *Dratz* and *Coberly* and by *Buchan* (3, 7, 8).

We have tested the sample rotation method with an instrument partly constructed at the Institute for Medical Research and Occupational Health. The purpose of our investigation was to find the optimal compromise between sensitivity and the measuring error due to the inhomogeneity of the sample. The method was evaluated by means of ^{85}Sr and ^{47}Ca.

EXPERIMENTAL

Our counter consisted of a Na I(Tl) scintillation crystal, size 2"×1³/₄" coupled to a single channel pulse height analyser Philips (PW: 4082; 4029/01; 4073; 4024/01; 4062; 4032) (Fig. 1).

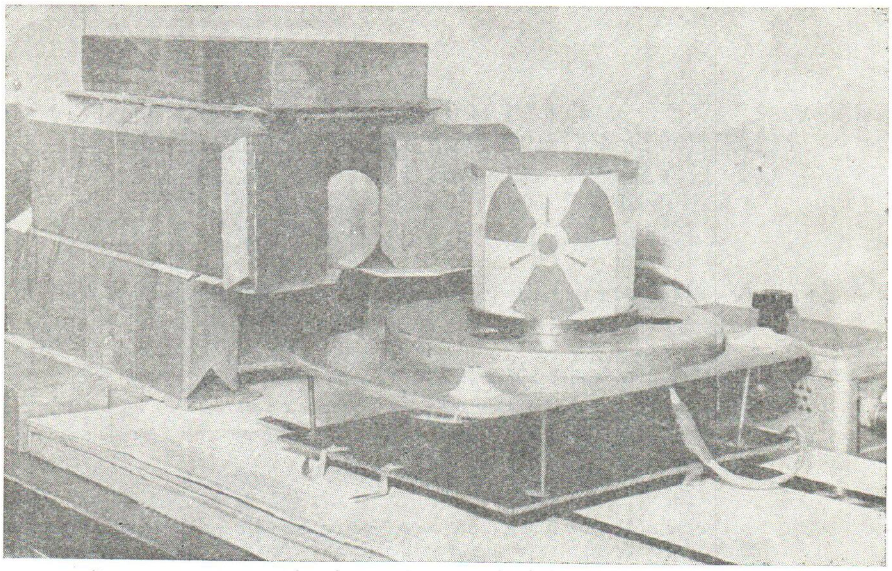

Fig. 1. *The rotating equipment for the determination of radioactivity in large samples of biological material*

The crystal was shielded with 2" thick lead bricks except the slit through which it was exposed to the radiation from the sample. In front of the crystal there was a platform for sample rotation 20 cm in diameter. The platform was rotated by means of a small electric motor (a gramophone turntable) adjustable for different speeds. A speed of 16 1/4 r p m was used. The platform together with the electric motor could be moved along a straight line on rails up to a maximum distance, H = 50 cm (from the face of the crystal to the axis of rotation of the sample) (Fig. 2).

The distance between the centre of rotation and the face of the crystal was determined by a meter scale parallel to the direction of the platform movement. The sample was placed in a plastic tube 1.4 cm in width and 0.7 cm high so representing approximately a point source. The small test tube was then put into a 700 ml plastic cylindrical container (ϕ = 10.8 cm, diam. 9 cm high). The container together with the point source was placed on the platform so that its axis of rotation coincided with the axis of rotation of the platform and was perpendicular to the cylindrical crystal (Fig. 1 and 2).

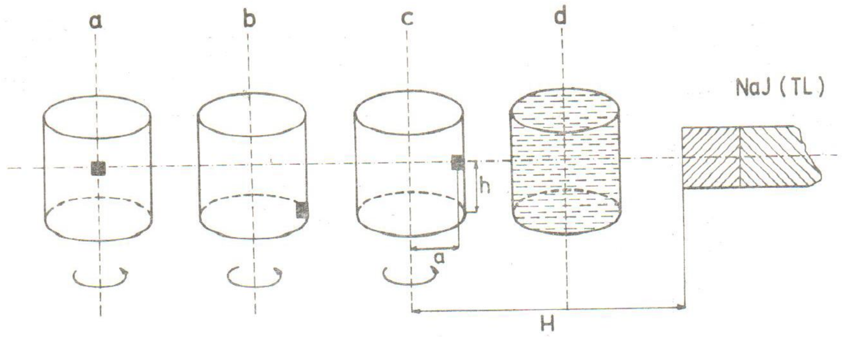

Fig. 2. *Schematic representation of three different rotating positions a, b and c of a small point source as related to the fixed crystal detector*

A small radioactive source of ^{47}Ca or ^{85}Sr was placed at three different positions *a, b* and *c* (Fig. 2). The large cylinder was then filled with water and the counts per minute from each source were determined when the table was rotated at 16 1/4 r p m. The radioactive source was then opened and the contents dispersed in water so simulating uniform distribution of radioactivity (geometry d, Fig. 2).

The intensity of radiation was determined for geometries a, b, c and d as counts per minute. Geometries a, b and c imitate three different examples of inhomogeneity, d being the standard to which they are compared. The point source rotates for geometry b and c describing a circle of radius *a* (the axis of rotation being at a distance H from the face of the crystal) which is taken as the distance from the axis of rotation of the container to the centre of the radioactive source. The counts per minute were measured for all four geometries for different distances (8, 10, 12 and 15 cm) for different channel widths (so termed the differential counting) and for full channel width (so termed the integral counting). The distance of 10 cm was found to be a convenient compromise.

As the example of a non-uniform source of radioactivity faecal samples were collected over 10 days following a known dose of ^{47}Ca or ^{85}Sr. The daily collections were assayed separately by the rotation method. These results were compared with separate measurements on a Tobor twin crystal gamma-ray counter (9) before and after ashing.

RESULTS

Table 1 shows the results of comparison of geometries a, b, c with the ideal, d, for ^{85}Sr and ^{47}Ca. It is seen, that the results improve with greater channel widths (expressed as a percentage of the discriminator bias level) especially for ^{85}Sr and that they are best for integral counting. The integral counting however could not be applied to double tracer studies. In that case within an energy interval of 0–2 MeV it is possible to work with a channel width of 8V (i. e. 31% of discriminator bias level

25.7V) with ^{85}Sr. At the same time ^{47}Ca can be determined within the photopeak of 1.3 MeV gamma ray using a channel width of 16 V (i. e. 25% of discriminator bias level 65.5 V) without being disturbed by ^{85}Sr (Fig. 3).

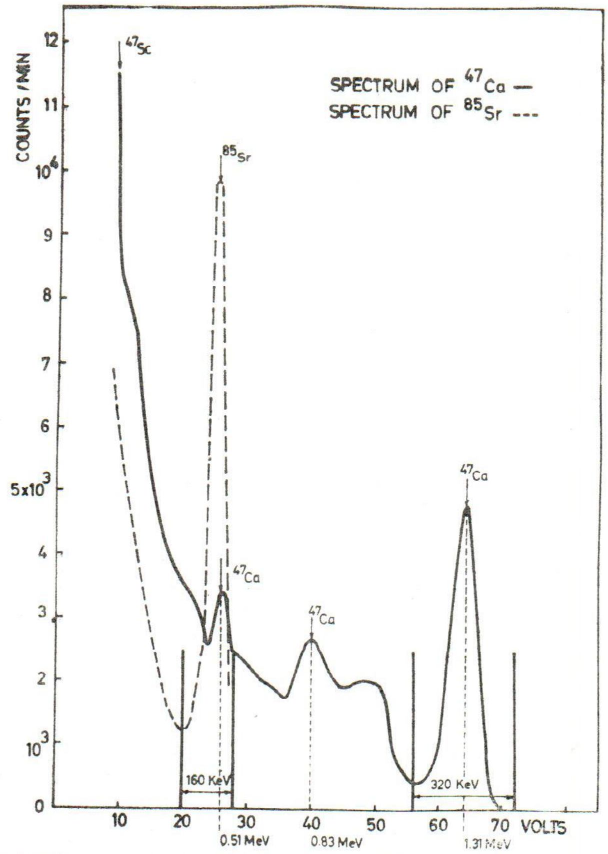

Fig. 3. ^{85}Sr and ^{47}Ca γ-ray pulse height spectra. The pulse heights recorded on the abscissa are directly proportional to γ-energies. Only the energies of the ^{85}Sr and ^{47}Ca principal peaks are indicated on the scale. The two discriminator settings in case of double tracer studies are indicated in the graph

The comparison of the measurements of the percent faecal excretion in non-ashed and ashed samples by the different methods is shown in Tables 2 and 3. The results of this comparison show that the rotation method gives very good results even at a distance less than 10 cm and that the doses determined in the non-ashed and the coresponding ashed specimens agree within 10%. It will be seen that for ^{47}Ca and ^{85}Sr it was not necessary to add water to the samples in order to achieve comparable results by different methods.

Table 1

Results of comparison of geometries a, b and c with the ideal d for different channel widths W expressed as % of discriminator bias level for a distance of H = 10 cm for ^{85}Sr and ^{47}Ca

^{85}Strontium						
	W=4%	W=8%	W=31%	W=62%	W=92%	Integral count
a/d	0.78(0.017)	0.79(0.012)	0.84(0.009)	0.89(0.008)	0.91(0.007)	0.97(0.005)
b/d	1.06(0.021)	1.05(0.019)	1.02(0.010)	1.02(0.008)	1.01(0.008)	1.01(0.005)
c/d	1.07(0.021)	1.08(0.013)	1.04(0.010)	1.03(0.009)	1.03(0.008)	1.02(0.005)
^{47}Calcium						
	W=6%	W=12%	W=25%	W=49%		Integral count
a/d	0.95(0.024)	0.92(0.019)	0.93(0.018)	0.91(0.015)		0.99(0.008)
b/d	0.98(0.025)	1.02(0.021)	1.04(0.020)	1.07(0.017)		1.03(0.008)
c/d	1.16(0.028)	1.12(0.022)	1.11(0.021)	1.12(0.017)		1.08(0.008)

The standard error due to counting is also given in parenthesis.

Table 2

Percent faecal excretion in non-ashed specimens of human faeces for different distances H for ^{85}Sr

Faecal samples	Percent excretion			
	Non-ashed samples (Philips)			
	H=8 cm	H=10 cm	H=12 cm	H=15 cm
1	2.75(0.035)	2.99(0.059)	2.77(0.062)	2.72(0.073)
2	1.53(0.030)	1.79(0.039)	1.64(0.041)	1.59(0.084)
3	1.56(0.030)	1.74(0.038)	1.65(0.041)	1.61(0.054)
4	0.64(0.016)	0.78(0.022)	0.71(0.023)	0.75(0.031)
5	0.54(0.015)	0.62(0.019)	0.57(0.021)	0.59(0.026)
6	0.40(0.014)	0.45(0.016)	0.42(0.017)	0.46(0.023)
7	0.42(0.013)	0.52(0.017)	0.50(0.019)	0.49(0.023)
8	0.28(0.012)	0.29(0.012)	0.30(0.014)	0.29(0.017)
9	0.10(0.002)	0.11(0.007)	0.11(0.006)	0.12(0.010)
10	0.16(0.008)	0.15(0.009)	0.16(0.010)	0.16(0.013)

Table 3

Percent faecal excretion in non-ashed and ashed specimens of human faeces for ^{85}Sr and ^{47}Ca

Isotope assayed	Faecal samples	Percent faecal excretion		
		Non-ashed samples Philips H=8 cm	Non-ashed samples Tobor	Ashed samples Tobor
^{85}Sr	1	2.75(0.035)	2.53(0.012)	2.68(0.010)
	2	1.53(0.030)	1.57(0.008)	1.45(0.008)
	3	1.56(0.030)	1.62(0.008)	1.55(0.009)
	4	0.64(0.016)	0.73(0.005)	0.64(0.005)
	5	0.54(0.015)	0.57(0.004)	0.54(0.004)
	6	0.40(0.014)	0.45(0.004)	0.41(0.004)
	7	0.42(0.013)	0.46(0.004)	0.44(0.004)
	8	0.28(0.012)	0.28(0.003)	0.23(0.003)
	9	0.10(0.002)	0.11(0.002)	0.10(0.002)
	10	0.16(0.008)	0.15(0.002)	0.14(0.002)
^{47}Ca	1	32.60(0.55)	33.60(0.17)	30.00(0.20)
	2	3.69(019)	3.40(0.05)	3.34(0.06)
	3	1.37(0.11)	1.42(0.03)	1.39(0.04)
	4	16.74(0.39)	15.63(0.11)	14.61(0.14)
	5	24.86(0.52)	22.85(0.14)	20.55(0.17)
	6	9.93(0.61)	8.88(0.10)	8.52(0.12)
	7	1.77(0.09)	1.87(0.03)	1.85(0.03)
	8	1.41(0.08)	1.49(0.03)	1.41(0.03)
	9	3.58(0.13)	3.68(0.04)	3.47(0.05)

Sensitivity of the instrument

If the activity necessary to give a pulse rate of three times the standard deviation above the background is taken as the minimum detectable activity (10) the lower limit of detectability for ^{85}Sr for differential and integral counting will be 8 nCi; for ^{47}Ca for differential counting 60 nCi, for integral counting 10 nCi.

DISCUSSION AND CONCLUSIONS

The purpose of our investigation was to evaluate the sample rotation method with ^{85}Sr and ^{47}Ca in order to find the optimal compromise between the sensitivity of our instrument for the determination of radioactivity of samples and the measuring error due to the inhomogeneity of the sample. From our experiments it is evident that the results of measurements improve with increasing channel width for differential counting and that they are best for wide channel counting. Similar results were obtained by *Buchan* (7) with different isotopes (^{51}Cr and ^{59}Fe) and different experimental conditions. From the results obtained for different H values we think that H = 10 cm would be a reasonable compromise between the sensitivity of the instrument and the measuring error due to the inhomogeneity of the samples.

From the measurements in non-ashed and the corresponding ashed samples we conclude that a distance of even less than 10 cm i. e. 8 cm would give good results. This was expected because faecal samples are more homogenous than the three geometries we used for our investigations. There is a very good agreement between the values in non-ashed and ashed samples. The differences are within statistical limits.

It is important to mention that in our study extreme geometries were used (a, b, c) which are improbable in biological samples.

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Sažetak

PROCENJIVANJE METODE ROTACIJE UZORKA U MJERENJU GAMA AKTIVNOSTI VELIKIH NEHOMOGENIH UZORAKA BIOLOŠKOG MATERIJALA

Evaluirali smo metodu rotacije za mjerenje radio-aktivnosti velikih uzoraka biološkog materijala uređajem djelomično konstruiranim na Institutu za medicinska istraživanja i medicinu rada. Cilj rada bio je naći optimalni kompromis između osjetljivosti mjerenja i mjerne pogreške uvjetovane nehomogenošću uzorka. Valjanost metode provjerena je određivanjem aktivnosti ^{85}Sr i ^{47}Ca. Na osnovi naših rezultata može se doći do zaključka da za određivanje radio-aktivnosti velikih uzoraka biološkog materijala mogu poslužiti relativno skromne aparature pristupačne svim kliničkim ustanovama, koje rade s radioizotopima.

Institut za medicinska istraživanja
i medicinu rada, Zagreb

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