# STRONTIUM 90 CONTENT IN MILK IN MEXICO **

Rebeca M. Nulman* and A. P. Báez†
Instituto de Geofísica
Comisión Nacional de Energía Nuclear
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*RESUMEN*

*Se ha desarrollado un método para la determinación de $^{90}Sr$ en leche. Este método presenta la ventaja de ser: sencillo, económico y permite procesar varias muestras, simultáneamente con poca supervisión. La recuperación de la actividad debida a $^{90}Sr$ es del orden de 90%.*

*En este trabajo se describe el método de muestreo y el procedimiento detallado de la separación radioquímica. Se presentan los resultados de 1963, 1964 y los primeros 8 meses de 1965. Estos resultados indican que el contenido de $^{90}Sr$ en la leche mexicana es bajo, en comparación con los resultados reportados para las leches durante el mismo período en los EE.UU.*

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* Head of the Decontamination Research Laboratory. Radiological Protection Direction, C.N.E.N.

† Former Technical Advisor, of the Radiological Protection Direction. At present Technical Advisor in Fluid Mechanics, and Magnetohydrodinamics. C.N.E.N.

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*ABSTRACT*

*A simple and cheap method for determining $^{90}Sr$ content in milk has been developed. This method permits running simultaneously several samples with little supervision. The recovery of the activity due to $^{90}Sr$ is of the order of 90%.*

*The sampling method and detailed radiochemical separation procedure are described and the results for 1963, 1964 and the first eight months of 1965 are given. The $^{90}Sr$ content in Mexican milk is low compared to those reported for milk in the United States of America.*

## INTRODUCTION

The most hazardous of the radioisotopes produced as nuclear débris after fission and fusion procedures is $^{90}Sr$, with its long half life, its relatively rapid passage through food chains, and the ease with which it is accumulated in the bones of men and animals[1].

Milk is one of the most important of foods; it is widely consumed and has a high Sr/Ca rate[2]. Studies undertaken in New York show that milk contributes almost 80% of the $^{90}Sr$ in the human diet, vegetables contribute little and the contribution from drinking water is negligible[3].

In scientific literature there are many references to methods to determine the quantity of $^{90}Sr$ in organic matter. The great majority of the methods proposed are based on the separation and counting of $^{90}Y$, and include the separation of alkali-earth metals from organic material[4,5,6,7,11] Sr-Ca separation[4,5,8,9], the removal of rare earths and trivalent cations[5,7], and yttrium separation, purification and counting[4,5,8,9].

The method used to determine $^{90}Sr$ in milk in Mexico, developed in this laboratory, after the U.S. Department of Health Education and Welfare, C.W. Thomas and F.E. Butler[5,6,7], has been designed to satisfy our special needs and takes our working conditions into account.

## APPARATUS AND TESTS

An apparatus for the ion exchange of milk on a column of ion-exchange Dowex 50×8 resin was used. A diagram of the apparatus is shown in fig. 1. It consists of a two-liter glass reservoir (A) joined to a chromatographic column (B), the chromatographic column is connected through a glass stopcock to a glass tubing for discharging the effluent into a 2000ml beaker (C). The shape of the glass tubing prevents the liquid draining below the resin level and the apparatus needs very little supervision.

C.W. Thomas[6] showed that metabolized Sr can be separated from milk using ion-exchange techniques with a chemical yield similar to added Sr. He injected $^{85}Sr$ intravenously into a sheep over a four-day period and a sample of the sheep's milk was obtained. Prior to injection, milk was collected and spiked with $^{85}Sr$. Good agreement was observed between the radiochemical yield of $^{85}Sr$ in both samples.

On that basis all the studies mentioned below were conducted on milk to which inorganic Sr had been added.

In order to measure the efficiency of the ion-exchange column technique to separate Sr from milk, a known quantity of strontium nitrate was added to milk and then passed through the column of resin at a rate of 10ml/min and the chemical yield of strontium was then determined, assuming the nonspiked milk to have a negligible amount of strontium as compared to the amount of strontium added. The results are shown in Table I.

To ascertain the extraction factor of yttrium 90 by liquid ion-exchange technique with HDEHP, two procedures were followed.

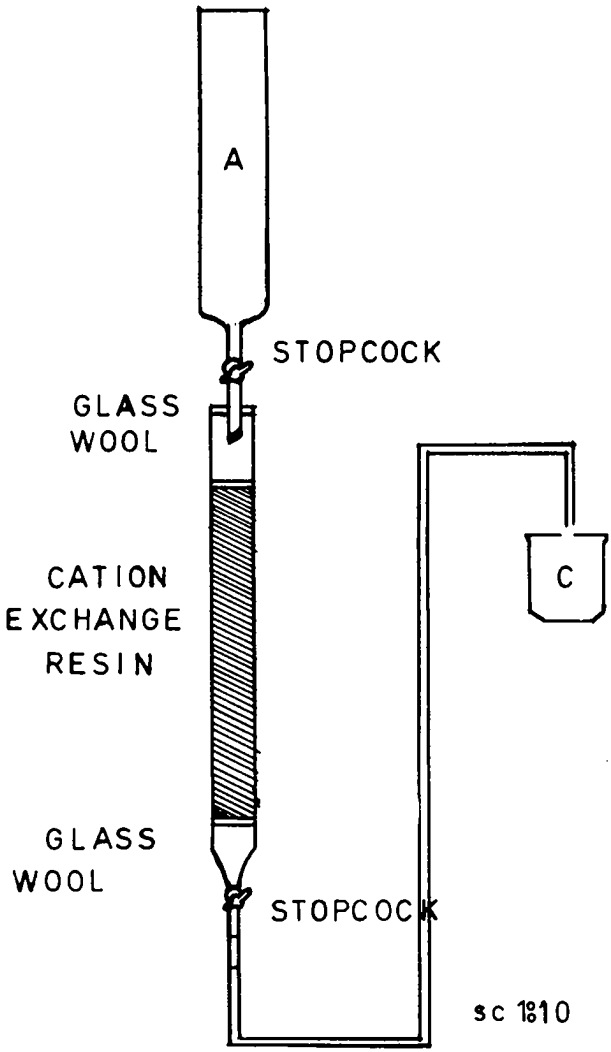
A
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TABLE 1

| Sr added | Sr recovered | % |
|---|---|---|
| mg | mg | |
| 88 | 83 | 94 |
| 88 | 82 | 93 |
| 88 | 85 | 97 |
| 88 | 89 | 100 |
| 88 | 86 | 98 |

TABLE 2

| HDEHP concentration | normal Y added g $Y_2O_3$ | Recovered g $Y_2O_3$ | % |
|---|---|---|---|
| 5% | .0545 | .047 | 87 |
| 10% | .0571 | .0559 | 98 |
| 0% | .0571 | .0543 | 96 |

TABLE 3

| $^{90}Sr - ^{90}Y$ added | $^{90}$theoretical | $^{90}Y$ actually | % |
|---|---|---|---|
| 140 d.p.m. | 70 d.p.m. | 68.3 ± 6.4 d.p.m. | 97 |
| 140 d.p.m. | 70 d.p.m. | 67.0 ± 6.2 d.p.m. | 96 |
| 140 d.p.m. | 70 d.p.m. | 69.0 ± 6.7 d.p.m. | 98 |

TABLE 4

| $^{90}Sr - {}^{90}Y$ added d.p.m. | $^{90}Sr$ recovered d.p.m. | $^{90}Sr$ in blank pCi | % |
|---|---|---|---|
| 310 | 144.6 | 1.4 | 93 |
| 310 | 148.2 | 1.3 | 96 |
| 310 | 132.3 | 1 | 85 |

After dissolving known quantities of non-radioactive strontium nitrate and ittrium nitrate in 0.08*N* HCl, and extracting yttrium from the mixture by the detailed technique mentioned below, the yttrium yield was determined by analyzing the nitric solution; the procedure was as follows: yttrium was precipitated as the hydroxide, filtered, redissolved with HCl, and reprecipitated as the oxalate, filtered through Whatman #42 filter paper, ashed in a muffle furnace at 900°C for 2 hours and weighed as $Y_2O_3$. The results are given in Table 2.

The second procedure used a 0.08*N* HCl solution of $^{90}Sr/{}^{90}Y$ of known activity with the strontium carrier only. Carrier-free yttrium 90 was separated and counted by the extraction procedure stated below. To assure $^{90}Y$ purity its decay scheme was followed. The results are given in Table 3.

The results shown in Table 4 give the strontium-90 recovery in spiked milk with a known activity of $^{90}Sr/{}^{90}Y$; it is rather high and yttrium-90 separation from other activities is good. Three non-spiked samples were used as blanks for comparison, but their activity being very low as compared to the spiked milk, they were neglected; nevertheless the results of their analysis are also shown in Table 4.

## SAMPLING

Ideal sampling technique includes taking daily samples from all dairies in a quantity proportional to their output and pooling all samples to form a monthly

average sample for analysis.

Unfortunately this method is very difficult to apply in Mexico, because Mexico City and the other areas of high consumption are supplied with milk by a large number of small dairies and their output is difficult to ascertain.

The actual sampling method used consists of pooling four weekly samples from the most important dairies to form a monthly sample. This is done in the cities of Mexico, Veracruz, Mérida, Ensenada and Chihuahua.

Mexico City is supplied by many dairies located in places around the city, so in order to ascertain the differences between the activity of milk from different sources, the Asociación de Productores de Leche Pura, A.C. (Pure Milk Producer's Association) Mexico City's most important milk-producers association, sends us 9 liters of milk, each from a different dairy, but with the same date of collection each month. In the laboratory, milk is pooled to form 5 groups according to the geographical location of the dairies.

Occasionally some samples from other parts of the Mexican Republic are analyzed.

## ANALYTICAL PROCEDURE

Reagents.

1. Strontium carrier: Strontium nitrate solution (88 mg/ml of Sr) in distilled water.

2. Buffer solution (6*M* ammonium acetate, 3*M* acetic acid adjusted to pH 5.5).

3. Ion-exchange resin: Dowex 50 × 8, 20-40 mesh in sodic form (see note 1).

4. Hydrochloric acid.

5. 2*M* sodium chloride solution.

6. Oxalic acid solution (saturated).

7. Ammonium hydroxide.

8. Nitric acid.

9. Di-2-ethyl-hexyl phosphoric acid solution, 10 and 20% *W/V* strenght in toluene (this reagent is sold by Union Carbide Corp. and is the only reagent that thas to be brought from abroad).

## TECHNIQUE

1. 1 ml of Sr carrier and 60 ml of buffer solution are added to a two-litter milk sample.

2. The milk is passed through the ion exchange column (after mixing) at a rate of 10 ml/min.

3. The resin is washed in the column with hot water and water at room temperature, until the effluent is transparent.

4. Approx. 1 liter of 3*N* HCl is passed through the column until no more Ca or Sr appears in the eluate.

5. 180 ml of saturated oxalic acid solution is added to the eluate and heated to near boiling. Neutralize with 6*N* $NH_4OH$.

6. Cool, store for 2 or 3 hours (or overnight) and filter through #42 Whatman filter paper with suction in a Büchner funnel. Wash the precipitate with distilled water. Discard the filtrate.

7. Dry and ignite the precipitate in a muffle furnace at 600 to 800°C for 2 hours.

8. Cool and dissolve the precipitate with 4*N* nitric acid and transfer the solution to a 250 ml beaker, washing the ashing vessel with 4*N* nitric acid.

9. Evaporate the solution to dryness.

10. Slurry the precipitate with 30 ml of 16*N* nitric acid and transfer it to a 50 ml centrifuge tube.

11. Centrifuge and discard the supernatant.

12. Add 30ml of 16*N* $HNO_3$, heat in a water bath for 10 minutes, stirring frequently. Cool in an ice bath.

13. Centrifuge and discard the supernatant (note 2).

14. Dissolve the precipitate in the least water possible and evaporate to dryness on a water bath.

15. Dissolve the residue with 60ml of 0.08*N* HCl and transfer to a separating funnel.

16. Extract the sample with 60ml of 20% HDEHP, shaking vigorously for two minutes, allow the phases to separate and discard the organic phase.

17. Store the bottom sample layer in a small polyethylene bottle for two weeks, the required time to reach secular equilibrium ($T_1$).

18. After $^{90}Y$ build-up transfer the solution to a separation funnel with 60ml of 10% HDEHP.

19. Shake the funnel for 2 minutes and allow the phases to separate. Drain off the bottom sample layer into a 250ml beaker for chemical yield determination (note 3). Note the time of extraction ($T_2$).

20. Wash the 10% HDEHP solution by shaking with two 60ml volumes of 3*N* $HNO_3$. Shake for two minutes for each extraction and combine the 3*N* $HNO_3$ solutions in a 150ml beaker.

21. Evaporate the 3*N* $HNO_3$ solutions to a small volume and transfer the solution (quantitatively) to a stainless steel planchet. Evaporate the solution to dryness under an infrared lamp.

22. $^{90}Y$ is counted in a low-background Nuclear Chicago beta counter. Note time of counting ($T_3$).

**NOTE 1.** The ion exchange resin is washed with water by decantation 3 times, slurried in water and transferred to the chromatographic column, where it settles on a glass wool stopper. 2*N* NaCl is passed through the resin until a pH of 6-7 is

attained in the effluent, then the column is washed with distilled water to eliminate any NaCl in excess.

**NOTE 2.** Calcium must be separated from Sr since it interferes with flamometric analysis of Sr for chemical yield.

**NOTE 3.** If determination of $^{89}Sr$ is also desired, Sr is precipitated at this stage with ammonium carbonate and beta counted for $^{90}Sr/^{89}Sr$, after $^{90}Sr$ analysis, the activity due to $^{90}Sr$ is deducted from total radiostrontrium activity.

## CALCULATION

The calculation method has been adapted from "Radionuclides Analysis of Enviromental Samples". The following symbols will be used:

$a$ = $^{90}Sr$ activity in pCi/l

$n$ = net counting rate in c.p.m. (total−background)

$A$ = efficiency of the counting arrangement, including backscattering from the stainless steel planchets

$B$ = ingrowth factor, i.e., the factor which takes into account the fact that after the time $T_1 - T_2$, secular equilibrium is not completely reached (for $T_2 - T_1$ = 2 weeks, B = 0.97)

$C$ = efficiency of chemical extraction

$D$ = exp $-0.693\ (T_2 - T_1/\tau)$, where $\tau$ is the $^{90}Y$ decay half life to take into account the decay between the second extraction to counting.

$E$ = sample volume in liters

$F$ = chemical yield which is determined measuring Sr concentration from the solution saved from steps 18 and 19, by the internal standard method[10]*.

*When the chemical yield is less than 50%, a great manipulation error is involved and the results are considered not reliable.

Putting

$$\eta = ABCDEF$$

then

$$a = \frac{n}{2.22\,\eta} \pm Q$$

where the error

$$Q = \frac{1.96\sqrt{n+b}}{2.22\,\eta}$$

Here b, the background counting rate, takes into account only the counting statistics and is given at the 90% confidence level.

## COMMENTS

The method used in Mexico by the Programa de Protección Radiológica of the Comisión Nacional de Energía Nuclear for $^{90}Sr$ analysis in milk was adapted from methods proposed in the literature in order to suit our special requirements of easily available reagents and equipment and very low $^{90}Sr$ contents in Mexican milk. This method has the following advantages: the procedures are easily carried out, chemical yield is good and there are few sources of error; it uses reagents that are both cheap and readily obtainable, it needs neither special installations nor requires constant technical supervision; one chemist may perform four to five analysis simultaenously over a period of four working days with the aid of one untrained assistant.

The results given are not analysed because this is beyond the scope of this paper but in general higher results where observed in zones where higher fission-product beta concentrations in surface air are currently observed and the last two months of 1964 showed a very low $^{90}Sr$ content in milk in accordance with very low beta-activity concentration in surface air.

## ACKNOWLEDGEMENTS

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## STRONTIUM 90 IN MEXICAN MILK

## R E S U L T S

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Villahermosa, Tab. | 14 - I - 63 | 4.0 | 2.9 |
| México, D.F. | 16 - I - 63 | 2.5 | 2.3 |
| México, D.F. | 14 - II - 63 | < 1.0 | < 1.0 |
| Acapulco, Gro. | 16 - II - 63 | 3.1 | 2.9 |
| México, D.F. | 19 - II - 63 | 6.5 | 5.8 |
| Toluca, Edo. de Méx. | 21 - II - 63 | 1.0 | 1.0 |
| Coapa, Edo. de Méx. | 8 - II - 63 | 2.2 | 1.9 |
| Texcoco, Edo. de Méx. | 8 - III - 63 | 2.0 | 1.7 |
| México, D.F. | III - 63 | 2.9 | 2.3 |
| Acapulco, Gro. | 16 - III - 63 | 8.7 | 7.5 |
| Sta. Bárbara, Edo. de Méx. | 3 - IV - 63 | 3.2 | 2.8 |
| Sn Juan del Río, Qro. | 3 - IV - 63 | 4.1 | 3.5 |
| Coapa, Edo. de Méx. | 3 - IV - 63 | 3.2 | 2.8 |
| Guadalajara, Jal. | 14 - IV - 63 | 3.6 | 2.7 |
| México, D.F. | IV - 63 | 4.1 | 3.6 |
| San Luis Potosí, S.L.P. | 17 - IV - 63 | 2.0 | 1.7 |
| Torreón, Coah. | 17 - IV - 63 | 1.8 | 1.5 |
| Sn. Juan del Río, Qro. | 2 - V - 63 | 7.1 | 6.3 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Texcoco, Edo. de Méx. | 2-V-63 | 4.9 | 4.3 |
| Toluca, Edo. de Méx. | 2-V-63 | 7.8 | 7.3 |
| Sta. Bárbara, Edo. de Méx. | 2-V-63 | 2.8 | 2.4 |
| Coapa, Edo. de Méx. | 2-V-63 | 3.1 | 2.7 |
| Texcoco, Edo. de Méx. | 7-VI-63 | 4.9 | 4.3 |
| Toluca, Edo. de Méx. | 7-VI-63 | 5.7 | 4.8 |
| Sta. Bárbara, Edo. de Méx. | 7-VI-63 | 9.0 | 7.2 |
| San Juan del Río, Qro. | 7-VI-63 | 4.9 | 4.1 |
| Coapa, Edo. de Méx. | 7-VI-63 | 9.9 | 8.2 |
| Coatzacoalcos, Ver. | VI-63 | 25.2 | 14.4 |
| México, D.F. | VI-63 | 4.1 | 4.0 |
| Texcoco, Edo. de Méx. | 6-VII-63 | 1.7 | 1.5 |
| Toluca, Edo. de Méx. | 6-VII-63 | 7.0 | 6.9 |
| Sta. Bárbara, Edo. de Méx. | 6-VII-63 | 8.3 | 7.5 |
| San Juan del Río, Qro. | 6-VII-63 | 8.3 | 7.5 |
| Coapa, Edo. de Méx. | 6-VII-63 | 4.9 | 4.3 |
| Sta. Inés Zacatelco, Tlax. | 20-VII-63 | 12.6 | 8.4 |
| México, D.F. | VII-63 | 16.1 | 15.5 |
| Coatzacoalcos, Ver. | VII-63 | 8.0 | 5.8 |
| Texcoco, Edo. de Méx. | 2-VIII-63 | 10.5 | 9.4 |
| Toluca, Edo. de Méx. | 2-VIII-63 | 11.0 | 9.9 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Sta. Bárbara, Edo. de Méx. | 2 - VIII - 63 | 6.8 | 6.4 |
| San Juan del Río, Qro. | 2 - VIII - 63 | 8.9 | 7.8 |
| Coapa, Edo. de Méx. | 2 - VIII - 63 | 6.8 | 5.7 |
| México, D.F. | 2 - VIII - 63 | 5.2 | 5.1 |
| Texcoco, Edo. de Méx. | 3 - IX - 63 | 6.6 | 5.6 |
| Toluca, Edo. de Méx. | 3 - IX - 63 | 4.6 | 4.1 |
| Sta. Bárbara, Edo. de Méx. | 3 - IX - 63 | 5.9 | 5.3 |
| San Juan del Río, Qro. | 3 - IX - 63 | 19.7 | 18.3 |
| Coaztacoalcos, Ver. | IX - 63 | 41.4 | 18.0 |
| Texcoco, Edo. de Méx. | 3 - X - 63 | 6.0 | 5.1 |
| Toluca, Edo. de Méx. | 3 - X - 63 | 3.4 | 2.9 |
| Sta. Bárbara, Edo. de Méx. | 3 - X - 63 | 3.3 | 2.8 |
| San Juan del Río, Qro. | 3 - X - 63 | 3.9 | 3.2 |
| Coapa, Edo. de Méx. | 3 - X - 63 | 2.6 | 2.2 |
| México, D.F. | X - 63 | 3.5 | 3.1 |
| Coatzacoalcos, Ver. | X - 63 | 15.3 | 11.6 |
| Texcoco, Edo. de Méx. | 6 - XI - 63 | 2.6 | 2.3 |
| Toluca, Edo. de Méx. | 6 - XI - 63 | 5.6 | 5.2 |
| Sta. Bárbara, Edo. de Méx. | 6 - XI - 63 | 2.2 | 2.1 |
| San Juan del Río, Qro. | 6 - XI - 63 | 2.7 | 2.4 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Coapa, Edo. de Méx. | 6-XI-63 | 1.0 | 1.0 |
| Coatzacoalcos, Ver. | XI-63 | 36.5 | 30.3 |
| Toluca, Edo. de Méx. | 8-I-64 | 10.2 | 8.1 |
| Sta. Bárbara, Edo. de Méx. | 8-I-64 | 3.3 | 2.6 |
| San Juan del Río, Qro. | 8-I-64 | 3.2 | 2.5 |
| Coapa, Edo. de Méx. | 8-I-64 | 1.5 | 1.4 |
| México, D.F. | I-64 | 1.3 | 1.0 |
| Texcoco, Edo. de Méx. | 4-I-64 | 2.2 | 1.9 |
| Toluca, Edo. de Méx. | 4-II-64 | 4.1 | 3.7 |
| Sta. Bárbara, Edo. de Méx. | 4-II-64 | 2.7 | 2.5 |
| San Juan del Río, Qro. | 4-II-64 | 3.0 | 2.5 |
| Coapa, Edo. de Méx. | 4-II-64 | <1.0 | <1.0 |
| Texcoco, Edo. de Méx. | 13-III-64 | 1.5 | 1.3 |
| Toluca, Edo. de Méx. | 13-III-64 | <1.0 | <1.0 |
| Sta. Bárbara, Edo. de Méx. | 13-III-64 | 2.0 | 1.7 |
| Coapa, Edo. de Méx. | 13-III-64 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 16-IV-64 | 2.9 | 2.5 |
| Sta. Bárbara, Edo. de Méx. | 16-IV-64 | 2.0 | 1.9 |
| San Juan del Río, Qro. | 16-IV-64 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 16-IV-64 | 1.1 | <1.0 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Texcoco, Edo. de Méx. | 15-V-64 | 3.82 ± 0.49 | 3.05 ± 0.38 |
| Toluca, Edo. de Méx. | 15-V-64 | 4.18 ± 0.53 | 3.64 ± 0.456 |
| Sta. Bárbara, Edo. de Méx. | 15-V-64 | <1.0 | <1.0 |
| San Juan del Río, Qro. | 15-V-64 | 2.1 ± 0.23 | 1.89 ± 0.172 |
| Coapa, Edo. de Méx. | 15-V-64 | 2.4 ± 0.38 | 2.0 ± 0.316 |
| Toluca, Edo. de Méx. | 16-VI-64 | 3.12 ± 0.9 | 2.88 ± 0.83 |
| Sta. Bárbara, Edo. de Méx. | 16-VI-64 | 4.0 ± 0.97 | 3.57 ± 0.86 |
| San Juan del Río, Qro. | 16-VI-64 | 2.43 ± 0.66 | 2.03 ± 0.55 |
| Texcoco, Edo. de Méx. | 16-VII-64 | 3.02 ± 0.5 | 0.87 ± 0.1 |
| Toluca, Edo. de Méx. | 16-VII-64 | <1.0 | <1.0 |
| Sta. Bárbara, Edo. de Méx. | 16-VII-64 | 3.59 ± 1.07 | 3.28 ± 0.97 |
| San Juan del Río, Qro. | 16-VII-64 | 4.31 ± 1.3 | 3.9 ± 1.2 |
| Coapa, Edo. de Méx. | 16-VII-64 | 4.69 ± 1.3 | 4.4 ± 1.12 |
| Mérida, Yuc. | 10-VII-64 to 31-VII-64 | 5.08 ± 0.7 | 5.08 ± 0.7 |
| Texcoco, Edo. de Méx. | 19-VIII-64 | 5.86 ± 1.43 | 4.80 ± 1.17 |
| Toluca, Edo. de Méx. | 19-VIII-64 | 1.14 ± 0.72 | 0.81 ± 0.51 |
| Sta. Bárbara, Edo. de Méx. | 19-VIII-64 | 2.90 ± 0.47 | 2.54 ± 0.41 |
| San Juan del Río, Qro. | 19-VIII-64 | 2.30 ± 0.90 | 1.17 ± 0.80 |
| Mérida, Yuc. | | 2.60 ± 0.75 | 2.30 ± 0.66 |
| México, D.F. | | 1.50 ± 0.80 | 1.40 ± 0.78 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Texcoco, Edo. de Méx. | 14-IX-64 | 1.5 ± 0.2 | 1.25 ± 0.16 |
| Toluca, Edol de Méx. | 14-IX-64 | 2.11 ± 0.86 | 2.06 ± 0.84 |
| Sta. Bárbara, Edo. de Méx. | 14-IX-64 | 2.65 ± 1.5 | 2.36 ± 1.14 |
| San Juan del Río, Qro. | 14-IX-64 | 3.55 ± 1.8 | 3.03 ± 1.52 |
| Coapa, Edo. de Méx. | 14-IX-64 | 4.39 ± 1.5 | 3.78 ± 1.29 |
| Veracruz, Ver. | IX-64 | 2.0 ± 1.7 | 1.36 ± 1.2 |
| Mérida, Yuc. | IX-64 | 7.37 ± 2.11 | 6.95 ± 2.0 |
| Ensenada, B.C. | IX-64 | <1.0 | <1.0 |
| México, D.F. | IX-64 | 7.4 ± 1.1 | 8.0 ± 1.2 |
| Chihuahua, Chih. | IX-64 | 1.16 ± 0.95 | 1.0 ± 0.82 |
| Texcoco, Edo. de Méx. | 15-X-64 | 3.39 ± 1.75 | 2.69 ± 1.44 |
| Toluca, Edo. de Méx. | 15-X-64 | 2.58 ± 0.7 | 2.01 ± 0.54 |
| Sta. Bárbara, Edo. de Méx. | 15-X-64 | 11.0 ± 4.0 | 10.9 ± 3.86 |
| Coapa, Edo. de Méx. | 15-X-64 | 5.0 ± 2.7 | 3.24 ± 1.75 |
| Veracruz, Ver. | X-64 | 7.17 ± 1.71 | 5.27 ± 1.25 |
| Ensenada, B.C. | X-64 | <1.0 | <1.0 |
| México, D.F. | X-64 | 1.25 ± 0.49 | 1.22 ± 0.48 |
| Ocoyoacac (Reactor's Zone) | 17-X-64 | 2.41 ± 0.92 | 1.56 + 0.59 |
| Joquicingo (Reactor's Zone) | 17-X-64 | 4.37 ± 2.29 | 2.87 + 1.5 |
| Reactor's Zone | 19-XII-64 | <1.0 | <1.0 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Chihuahua, Chih. | XII-64 | 1.55 ± 0.7 | 4 ± 0.6 |
| Mérida, Yuc. | XII-64 | <1.0 | <1.0 |
| Texcoco, Edo. de Méx. | 15-I-65 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 15-I-65 | <1.0 | <1.0 |
| Sta. Bárbara, Edo. de Méx. | 15-I-65 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 15-I-65 | <1.0 | <1.0 |
| Veracruz, Ver. | 15-I-65 | <1.0 | <1.0 |
| Reactor's Zone | 28-I-65 | 2.2 ± 1.12 | 1.92 ± .97 |
| Chihuahua, Chih. | I | 1.0 ± 76 | 0.57 ± .49 |
| Texcoco, Edo. de Méx. | 18-II-65 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 18-II-65 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 18-II-65 | <1.0 | <1.0 |
| Mérida, Yuc. | II | <1.0 | <1.0 |
| Chihuahua, Chih. | III | <1.0 | <1.0 |
| Texcoco, Edo. de Méx. | 18-III-65 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 18-III-65 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 18-III-65 | 1.05 ± .49 | .85 ± 0.4 |
| México, D.F. | III | 1.63 ± .65 | .81 ± .45 |
| Mérida, Yuc. | III | 2.19 ± 0.796 | 1.7 ± 0.65 |
| México, D.F. | 7-IV-65 | 1.61 ± 0.73 | 1.32 ± .60 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Veracruz, Ver. | 31-III-65 | 1.62 ± .87 | 1.12 ± 0.6 |
| Texcoco, Edo. de Méx. | 22-IV-65 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 22-IV-65 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 22-IV-65 | <1.0 | <1.0 |
| Chihuahua, Chih. | 23-IV-65 | 5.35 ± 1.80 | 4.61 ± 1.55 |
| Veracruz, Ver. | 17-IV-65 | <1.0 | <1.0 |
| Mérida, Yuc. | 28-IV-65 | 1.23 ± .55 | 1.41 ± .66 |
| México, D.F. | 14-V-65 | 1.31 ± 0.59 | 1.26 ± .57 |
| Ensenada, B.C. | IV | <1.0 | <1.0 |
| México, D.F. | 14-V-65 | <1.0 | <1.0 |
| Texcoco, Edo. de Méx. | 17-V-65 | <1.0 | <1.0 |
| Toluca, Edo. de Méx. | 17-V-65 | --- | --- |
| Sta. Bárbara, Edo. de Méx. | 17-V-65 | <1.0 | <1.0 |
| Coapa, Edo. de Méx. | 17-V-65 | 1.19 ± 0.54 | 0.96 ± 0.44 |
| México, D.F. | V | <1 -- | <1.0.1 |
| Coahuixtla, Mor. | V | --- | <1.0 |
| Mérida, Yuc. | V | --- | <1.0 |
| Texcoco, Edo. de Méx. | 16-VI-65 | --- | <1.0 |
| Toluca, Edo. de Méx. | 16-VI-65 | --- | <1.0 |
| Sta. Bárbara, Edo. de Méx. | 16-VI-65 | --- | <1.0 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| San Juan del Río, Qro. | 16-VI-65 | 1.58 | 1.87 |
| Coapa, Edo. de Méx. | 16-VI-65 | - - - | <1.0 |
| México, D.F. | VI-65 | 2.33 | 2.59 |
| Mérida, Yuc. | VI-65 | 1.0 | 1.0 |
| Veracruz, Ver. | VI-65 | <1 | <1 |
| Coahuixtla, Mor. | VI-65 | 2.37 ± 0.82 | 1.88 ± .65 |
| Chihuahua, Chih. | VI-65 | <1 | <1 |
| Veracruz, Ver. | 10-VII-65 | 1.88 ± 0.85 | 1.31 ± 0.59 |
| Texcoco, Edo. de Méx. | 16-VII-65 | <1 | <1 |
| Toluca, Edo. de Méx. | 16-VII-65 | 3.04 ± 0.89 | 0.37 ± 0.67 |
| Sta. Bárbara, Edo. de Méx. | 16-VII-65 | 2.56 ± 0.99 | 1.48 ± 0.58 |
| San Juan del Río, Qro. | 16-VII-65 | 6.73 ± 1.96 | 4.28 ± 1.25 |
| Coapa, Edo. de Méx. | 16-VII-65 | 1.35 ± 0.67 | 1.06 ± 0.53 |
| Mérida, Yuc. | VII-65 | 1.21 ± 0.58 | 1.83 ± 0.4 |
| México, D.F. | VII-65 | 2.08 ± 0.74 | 1.89 ± 0.67 |
| México, D.F. | VII-65 | <1 | <1 |
| Chihuahua, Chih. | VII-65 | <1 | <1 |
| Veracruz, Ver. | 10-VIII-65 | <1 | <1 |
| Texcoco, Edo. de Méx. | 17-VIII-65 | <1 | <1 |
| Veracruz, Ver. | 14-VIII-65 | 2.64 ± 1.47 | 1.97 ± 1.1 |

| Sampling location | Date | pCi $^{90}$Sr/liter/milk | pCi $^{90}$Sr/gram Ca |
|---|---|---|---|
| Coahuixtla, Mor. | 23 - VIII - 65 | <1 | < 1 |
| Ensenada, B.C. | VIII - 65 | 1.37 ± 0.88 | 1.31 ± 0.85 |
| México, D.F. | 31 - VIII - 65 | 2.30 ± 1.05 | 2.09 ± 0.95 |

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