CAESIUM TRANSFER TO PLACENTA, URINE AND HUMAN MILK

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1. INTRODUCTION

After the Chernobyl accident few measurements on radioactive contamination of maternal milk, placenta and urine of nursing mothers were carried out. Two previous studies on breast milk contamination were conducted in different Italian areas [1,2] by the Physics Department of the National Institute of Health (Laboratorio di Fisica, Istituto Superiore di Sanità).

In the first study[1], conducted in collaboration with the Epidemiological Unit of the Lazio District, I-131, Cs-134 and Cs-137 concentrations were measured in mixed breast milk samples pooled from 5-10 women in the first week after delivery, from May 1986 to December 1987, in the Rome area.

The second research was conducted, in collaboration with the Lecco Hospital, in 1989 on a group of women living in the Como Lake area (Lombardia), which was one of the areas of Northern Italy most heavily affected by Chernobyl fallout, because of intensive rainfall in the first few days after the accident. The specific diet and caesium content in maternal milk[2] were studied recruiting pregnant women at the "respiratory autogen training" course.

In this case, Cs-137, Cs-134 and K-40 concentration in placenta and urine of the mothers under study had also been measured. Aim of this paper is to discuss these data and investigate the relationship between Cs-137 contamination of maternal milk, placenta and urine as a contribution to a better understanding of caesium metabolism in pregnant and nursing women.

2. MATERIALS AND METHODS

Twenty seven women, mean age 29, who delivered at term of gestation, have been recruited in the study. They were interviewed by a physician and a nurse and followed personally by the same nurse till the end of the milk collection. Their diet was investigated both by personal interviews and special personal diaries of their consumption[2]. At delivery their placenta was kept and during puerperium a urine sample was taken from a 24 h collection in day 3 after delivery (unluckily the information about the total volume of the 24 h collection was lost). Finally each mother had to collect 15-20 ml of mature milk from the 10^{th} to the 40^{th} day after delivery, in order to get samples of about 450 ml. All milk, urine and placenta samples were measured in Marinelli geometry with two high purity germanium detectors (26% and 38% of efficiency). They were shielded by 10 cm of lead and had been calibrated with an Amersham calibration source QCY44 (ρ=1 g/cm^3). The background of the systems was measured repeatedly over long periods and subtracted from the spectra. The measurement duration was chosen in order to have the statistical uncertainty on the Cs-137 peak equal to about 5%.

The milk samples (450 ml) and urine samples (1 liter) were measured without previous treatments, whereas the placentae were blended in order to be put in the Marinelli beaker. They had a weight between 250 and 430 g and a volume lower than 450 ml. Therefore, in order to use the same calibration geometry and density, double distilled water was added and mixed, after having checked its radioactive background. The samples so obtained had a mean density equal to 1.04 ± 0.10 g cm^{-3}.

3. RESULTS

From the group of 27 mothers participating in the study, 21 complete cases are available, because a hypogalactic condition arose in 6 mothers, not allowing the milk collection. However, the placenta and the urine samples of these 6 mothers were nevertheless kept and mother's and infant's personal data together with food consumption data had previously been collected.

Concentrations of Cs-137 and K-40 were assessed in all the biological samples. Cs-134 was detected only in a certain number of samples and the ratio of its concentration to the Cs-137 concentration was in good agreement with that detected in Europe in May 1986, taking into account the relevant half-lives.

In the previous study[2] the mean value of daily Cs-137 diet intake was calculated by using the mean daily diet for each mother and the Cs-137 food concentration in the Como area; it resulted equal to about 2.1 Bq/d and the largest contribution came from meat. The Cs-137 transfer factor from woman's diet to maternal milk was evaluated both by using a simplified milk compartment model and as the ratio of Cs-137 concentration in milk to the daily intake. The two values - almost coincident - are comparable with that obtained in the first study[1] and with those available in the literature, which are in the range 0.1-0.3 [3].

In figures 1 and 2 the Cs-137 and K-40 concentrations in 21 maternal milk, 27 placenta and 27 urine samples are shown. The uncertainties on the measurements (one standard deviation) are from 2 to 10% for Cs-137 and 1-6% for K-40.

The data of the 21 women and 21 newborns of the complete study are the following. Mean age at delivery was 28.3 years (SD 2.8; range 25-34); all pregnancies were at term, with mean gestational age 40 weeks (SD 1.5); 17 were primiparae and 4 multiparae with previous positive breast-feeding experience. One mother out of 21 underwent caesarian section. The mean weight of the newborn was 3303 g (SD 441). The mean body mass index (Quetelet's index) of the mothers was 0.21 (range 0.18 - 0.27).

In table 1 the mean values and ranges of the Cs-137 and K-40 concentrations and their ratios are summarized for the three types of biological samples from the 21 women of the complete study.

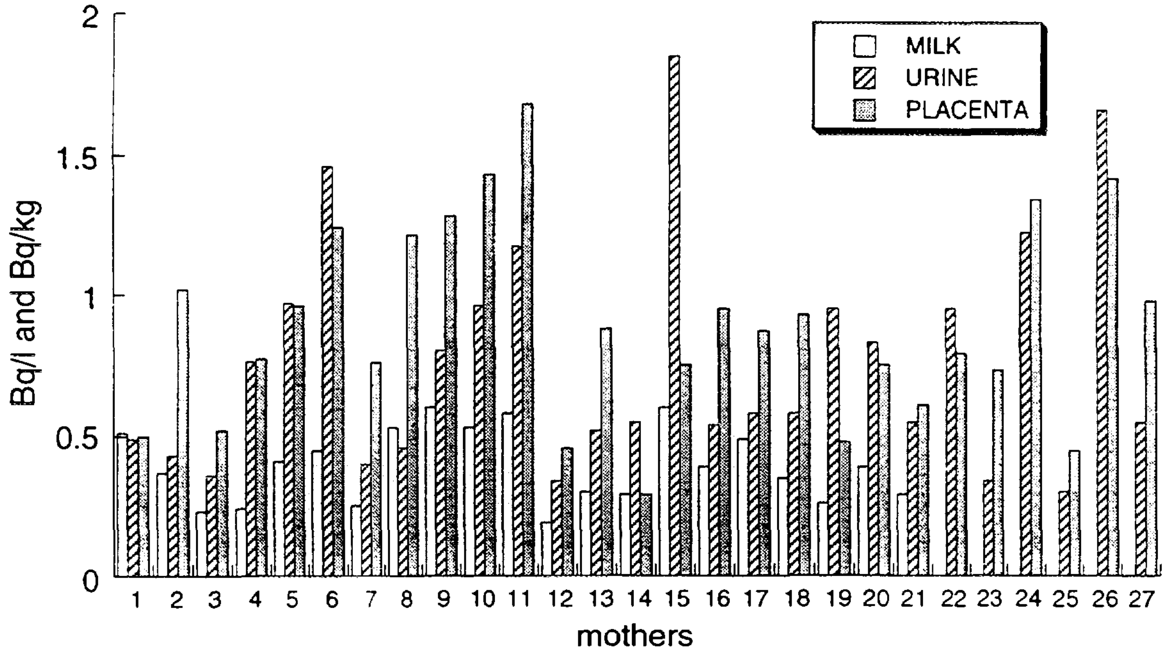

Figure 1. Cs-137 concentration in 21 samples of maternal milk and 27 samples of placenta and urine.

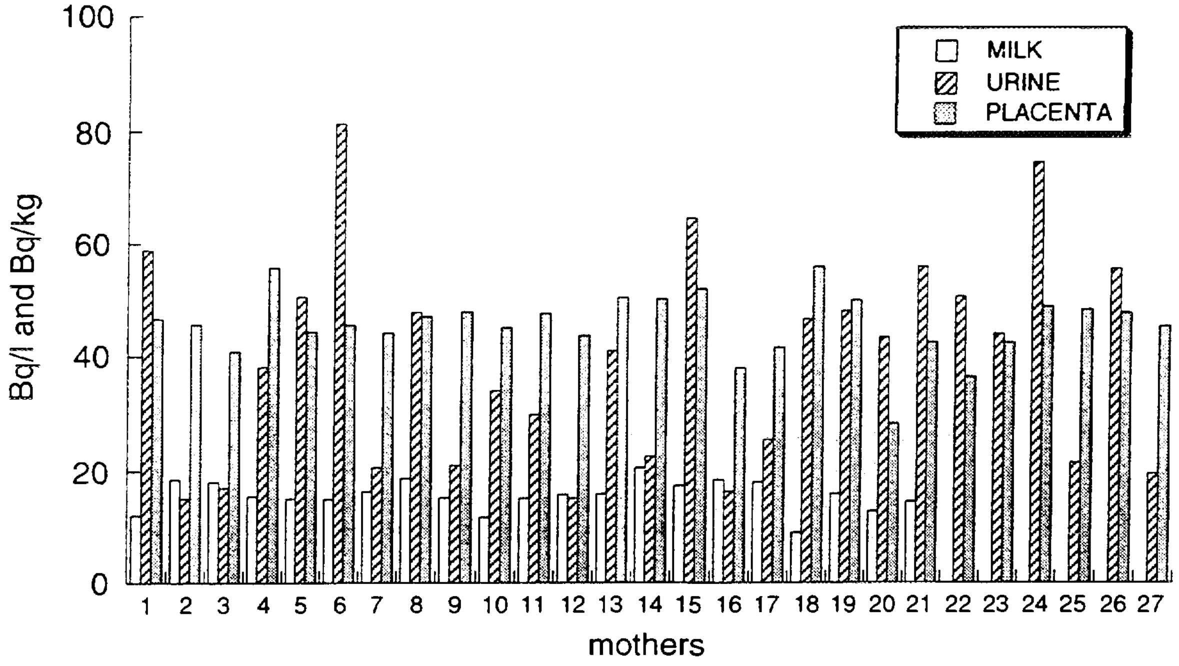

Figure 2. K-40 concentration in 21 samples of maternal milk and 27 samples of placenta and urine.

Table 1. Cs-137 and K-40 concentration and their ratio in maternal milk, placenta and urine for the 21 mothers.

	average	standard deviation	range
^{137}Cs in maternal milk (Bq/l)	0.39	0.13	0.19-0.60
^{40}K in maternal milk (Bq/l)	15.7	2.7	9.0-20.6
^{137}Cs / ^{40}K in maternal milk	0.026	0.011	0.012-0.045
^{137}Cs in placenta (Bq/kg)	0.87	0.35	0.29-1.68
^{40}K in placenta (Bq/kg)	45.9	6.1	28.3-55.9
^{137}Cs/^{40}K in placenta	0.019	0.008	0.006-0.035
^{137}Cs in urine (Bq/l)	0.74	0.38	0.34-1.85
^{40}K in urine (Bq/l)	37.7	18.5	15.0-81.2
^{137}Cs/^{40}K in urine	0.022	0.009	0.008-0.039

The interest in measuring K-40 is connected to the fact that potassium is present in all biological tissues and fluids and - due to its remarkable constant concentration in most of them and to its chemical similarity with caesium - particularly in the past it has been used in studying caesium transfer from the environment to the human body (e.g. from diet to maternal milk[4]). In addition, the constant isotopic abundace of K-40 in potassium makes possible the use of its concentration instead of the total potassium one[1].

The K-40 concentration in maternal milk in the table shows a low variability in comparison with that of Cs-137. This result is confirmed by data in the literature: as a general rule, mothers supply a steady potassium content (the same is true for other substances) whatever their feeding is, even when they are seriously undernourished.

Data from placenta samples also indicate a rather steady potassium content, whereas variability increases for caesium. This is not surprising, as the potassium content of a body organ is only partially related to the intake of this element, and complex metabolic mechanisms from intake to excretion help stabilizing potassium content in human body. On the contrary, the content of caesium in body organs is more dependent on its intake and on body content.

As to urine samples, interpreting data is more difficult. First, it would have been necessary to adjust potassium concentration for daily diuresis. Indeed, it is possible that individuals whose diuresis is higher should have less potassium concentration over the same total excretion; second, a high variability is not incredible, because urinary excretion of potassium is the most important way for the human body to stabilize potassium content when intake varies. Moreover, in order to better understand the real change in potassium excretion, it would be necessary to adjust the value of potassium urinary excretion over that of creatine urine excretion in the same individual (that is a relevant element for kidney functioning).

The correlation between values of Cs-137 concentrations measured in maternal milk, placenta and urine has been studied by using a linear regression, in order to verify if a simple law can be established between Cs-137 in these biological samples.

Data available in literature (see e.g. the review in [5]) show that caesium is distributed uniformely in the body, therefore Cs content of placenta could be an estimate of the total body content, once ascertained - as in this case - that the placentae come from healthy women with a physiological pregnancy and with no alteration of the placenta's flux, a possible cause of differences in caesium concentrations.

Moreover, it would be of the utmost importance to ascertain the existence of a linear correlation between Cs-137 content in mothers' milk and in urines. In fact, if this simple correlation is confirmed, the advantage of the urine samples analysis could be represented by the possibility of undertaking rapid surveys on large groups of nursing women and obtaining information about Cs-137 radiocontamination of maternal milk.

In Fig. 3 the Cs-137 concentrations in placenta versus corresponding values in maternal milk are reported. The regression line was obtained with a preliminary statistical analysis of the data, without taking into account the uncertainties of Cs-137 concentration in milk and therefore treating it as the independent variable. With this hypothesis the correlation coefficient results to be equal to 0.7 ($p=0.0004$). On the other hand treating Cs-137 concentration in placenta as the independent variable the correlation results weaker ($r=0.58$; $p=0.0063$). It is obvious that the assumption of treating one of the two magnitudes as without uncertainty underestimates the uncertainty on the correlation parameters; however, in the limit of this preliminary analysis of the data a rough linear dependence between the two Cs-137 concentration seems to come out.

In Fig.4, the Cs-137 concentrations in milk versus corresponding values in urine are reported, with the regression line. In this case the correlation coefficient results to be equal to 0.56 ($p=0.008$). Exchanging the two variables, r results to be 0.54 ($p=0.011$). However, in this case the scarse correlation between urine and milk values could partially be ascribed to potassium variability in urines. Thus, an eventual deepening of this study should aim at measuring creatine content in urine samples (which have been kept and are still frozen), in order to better understand the problem. Moreover, another type of correlation can be hypothesized between the two magnitudes and will be verified in a future.

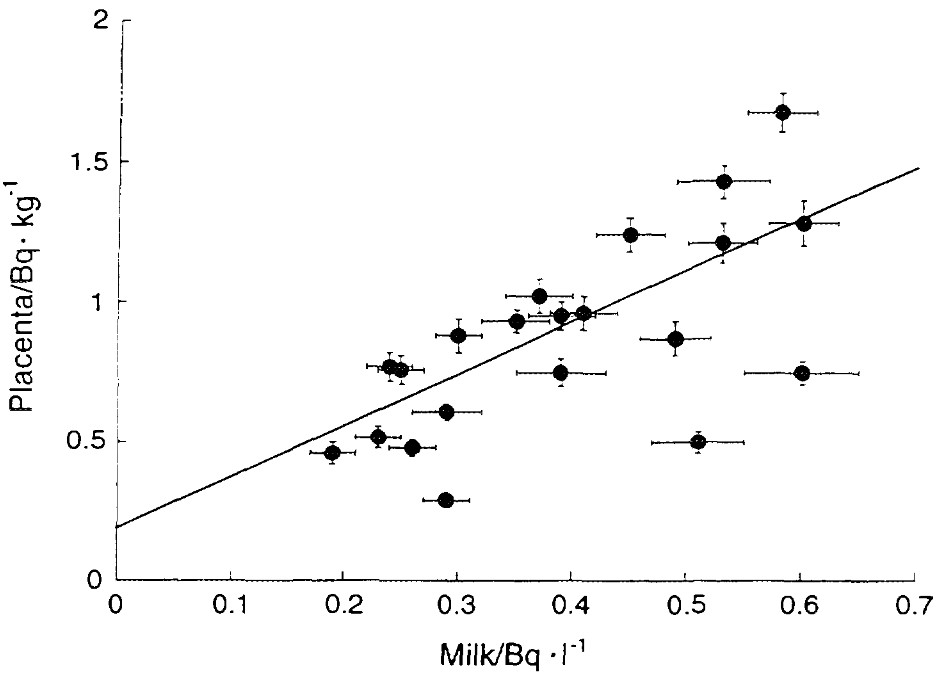

Figure 3. Cs-137 concentration in placenta versus Cs-137 concentration in maternal milk and linear regression.

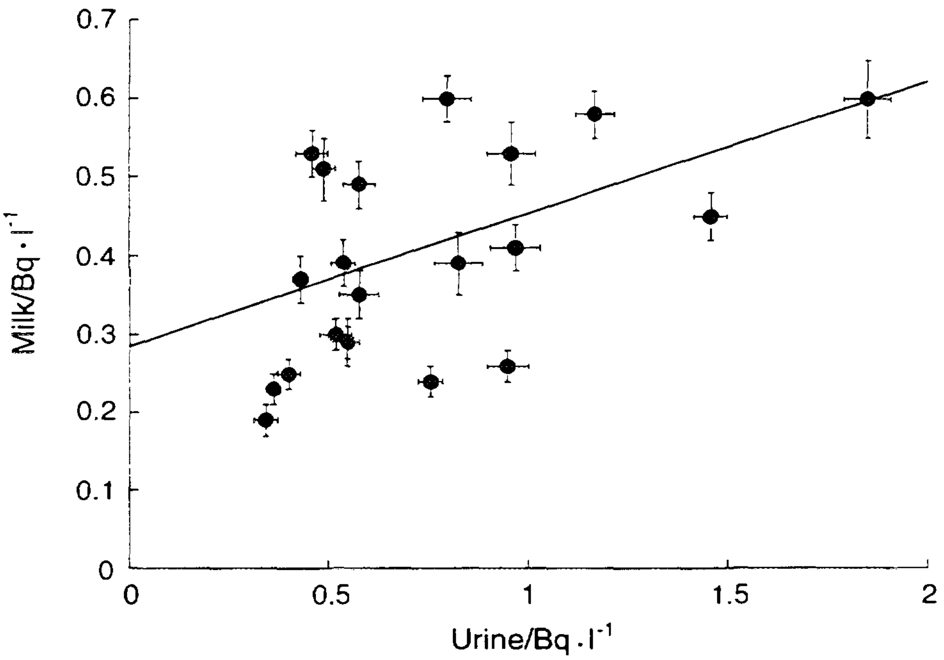

Figure 4. Cs-137 concentration in maternal milk versus Cs-137 concentration in urine and linear regression.

The transfer factor of Cs-137 from mother's diet to placenta (f_p) was calculated for each woman as the ratio of its concentration in mother's placenta to the daily intake. Its mean value is 0.5±0.2 d kg^{-1} with a range from 0.15 to 0.76 d kg^{-1}. Only a very few studies dealing with Cs-137 radioactivity in placenta have been carried out after the Chernobyl accident. In Italy one research regarding the Cs-137 levels in placenta was conducted from June 1986 to September 1987[6]; the value obtained for f_p was 0.48 d kg^{-1}.

Using mean daily intake values for the 21 women and the dose per unit intake coefficients[7], the mean committed effective dose to foetus for Cs-137 intake by mother's ingestion for the year including pregnancy was also evaluated. This dose is equal to ~10 μSv. It is also possible to evaluate[7] the mean body activity of the infant at birth time; the value obtained is equal to ~15 Bq.

4. CONCLUSIONS

In this paper the correlation between Cs-137 radioactive contamination of maternal milk, placenta and urine has been studied on a group of 21 women living in the Como Lake area.

As to urines, this study aimed at verifying the existence of a simple correlation between Cs-137 concentration in maternal milk and its concentration in urines, so that this last biological sample could be used for a quick assessment of caesium content in maternal milk. The obtained results do not seem to confirm this assumption completely. However, the work in progress, that is the evaluation of urine creatine and successive analyses of the data, hypothesizing different types of correlations, would improve the comprehension of the transfer from one compartment to the other.

The K-40 concentrations of maternal milk, placenta and urine have been measured and are discussed. A possible extension of this work would be the study of the ratio Cs/k in the mother's diet and their milk, placentae and urine.

Moreover, the Cs-137 transfer factor from diet to placenta was calculated; the obtained value is in good agreement with that evaluated by other authors.

Finally, the Cs-137 mean effective dose to foetus by mother's ingestion of contaminated food and the mean newborn body activity were assessed.

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