ASSESSMENT OF ^{210}PO EXPOSURE FOR THE ITALIAN POPULATION

G.F. Clemente, A. Renzetti, G. Santori and F. Breuer

Department of Radiation Research, CSN-Casaccia, CNEN, Roma, Italy.

The transfer to man of the normal environmental levels of the naturally occurring ^{210}Pb and of its descendant ^{210}Po is considered to contribute a large fraction of the natural radiation dose to man from internally deposited radionuclides (8). While ^{210}Pb being a beta emitter, contributes a small fraction of the entire dose due to the ^{210}Pb series, the alpha emitter ^{210}Po can be taken as the largest concurrent to the total natural internal dose to the skeleton of members of the general population (8).

^{210}Po has by itself a short effective half-life in the human body (6), which reduces its ability to accumulate in tissue, while the parent nuclide ^{210}Pb due to both its long physical half-life and metabolic behaviour in man, accumulates in bone(6). However, the ^{210}Po formed from ^{210}Pb in bone, it appears to remain in the skeleton in equilibrium with its parent (6). Therefore the knowledge of the pathways from environment to man and of the metabolic properties of ^{210}Pb and ^{210}Po is needed to assess the natural radiation dose due to the ^{210}Po burden in the members of the public. The dietary intake of ^{210}Pb is usually considered the main source of the ^{210}Pb - ^{210}Po internal burden in the general population (4, 7-8).

Increases of ^{210}Pb - ^{210}Po skeletal burden have been reported (1, 3, 6) in subjects exposed in uranium mines and spas to high levels of radon and daughter which are the progenitor of the ^{210}Pb series.

In this paper are summarized the experimental data needed to evaluate the ^{210}Po internal burden and the relative dose given to members of the general italian population and to those groups of subjects which are exposed in non uranium mines and spas to high radon and daughter air concentration.

MATERIALS AND METHODS

The ^{210}Po content, reported to the sampling time by correcting for decay and ingrowth from ^{210}Pb, has been measured in the following items: - About 40 samples of complete daily diet collected in six different regions of Italy and referred to adult members of the public.

- About 40 samples of urinary excretion collected from adult members of the public both non-smokers and smokers.

- More than 150 samples of urinary excretion collected from subjects working in spas and in non-uranium mines.
- About 20 samples of tooth and bone collected at various ages from members of the public.

The ^{210}Pb content, reported to the sampling time, was measured in most samples. The ^{210}Pb analysis has not been performed in those samples where the long time elapsed between collection and analysis was sufficient to give equilibrium conditions between the components of the ^{210}Pb series at the time of the analysis. The analytical procedure employed to determine ^{210}Pb and ^{210}Po in the various samples considered has been described in detail elsewhere (4). The method is based on a coprecipitation of polonium with manganese dioxide after a wet ashing of the sample. The ^{210}Po plated on silver disk is then measured by solid state detector spectrometry. The chemical yield of any analysis is tested by using ^{208}Po as an internal standard. The ^{210}Pb was evaluated from the ^{210}Po ingrowth in the sample by repeating the ^{210}Po analysis some months after the initial analysis.

RESULTS AND DISCUSSIONS

In table 1 are summarized the data referred to the main components of the metabolic balance of ^{210}Pb - ^{210}Po, evaluated on the basis of the ^{210}Pb - ^{210}Po content measured in the analyzed samples.

TABLE 1. Summary of the components of the ^{210}Pb - ^{210}Po metabolic balance in adult members of the general italian population.

Daily intake (Bq/day)	^{210}Pb	^{210}Po
Ingestion (Diet+Water)	0.11	0.11
Inhalation (non smoker)	0.006	0.0007
Daily excretion (Bq/day)		
Feces	0.095	0.095
Urine	0.015	0.015
Total Body Burden (Bq)	26	23
Skeletal Burden (Bq)	20	16

The daily inhalation has been calculated by measuring the ^{210}Pb ^{210}Po concentration in some air samples. The daily fecal excretion has been evaluated by applying the recently reported value (7) of the (daily fecal excretion) / (daily urinary excretion) ratio to the

urinary excretion measured in our subjects. The ^{210}Pb - ^{210}Po concentrations measured in teeth have been found not significantly different from those in bone samples, the mean ^{210}Po concentration value ± S.E. being 3.2 ±0.5 mBq/g. The data of table 1 should be considered entirely indicative of the ^{210}Pb - ^{210}Po intake, excretion and internal burden of the non-smoker adult members of the general italian population, owing to the large individual variability of the ^{210}Pb - ^{210}Po excretion rates at natural levels (5). Furthermore the daily dietary intake of ^{210}Pb - ^{210}Po has been found quite variable as a function of many factors (4). The highest ^{210}Pb - ^{210}Po daily dietary intake (0.3 Bq/day) being measured in diet samples collected in an area with high natural background. The mean ^{210}Pb - ^{210}Po daily intake measured in Italy is in good agreement with the data reported (4,8) for other european countries, while is higher than in some extraeuropean countries (4,8).

A mathematical model has been developed on the basis of the data given in table 1 to describe the metabolic behaviour in man of the systemic ^{210}Po and it should be considered valid for any introduction of ^{210}Po into the systemic compartment of the human body. A detailed description of the model, reporting the retention function in soft tissue and bone and the urinary excretion function for ^{210}Po, is given in (2). These functions have been used to evaluate the ^{210}Pb - ^{210}Po body burden of the subjects exposed to high levels of radon and daughter on the basis of their ^{210}Pb - ^{210}Po daily excretion. The model has been satisfactorily tested on ^{210}Pb - ^{210}Po intake and excretion data reported by other authors (7).

In table 2 are summarized the ^{210}Pb - ^{210}Po internal burden and the resulting dose rate to the skeleton of four groups of subjects selected according to the origin of the ^{210}Pb - ^{210}Po exposure.

TABLE 2. Body burden and yearly dose rate for adult members of the italian population according to the origin of exposure.

Population Group	Body burden (Bq)				Yearly dose rate to the skeleton (mGy/year)
	Skeleton		Soft Tissue		
	^{210}Pb	^{210}Po	^{210}Pb	^{210}Po	
General population non smoker	20	16	6	7	0.07
General population smoker	31	20	9	11	0.10
Non-uranium miners	150	110	30	25	0.60

Spa employees	480	370	110	90	2

The smoker subjects have a ^{210}Pb - ^{210}Po urinary excretion significantly higher than the non smokers, thus confirming the importance of smoking among the various natural sources of ^{210}Pb ^{210}Po contamination in man. A detailed discussion of the data reported in table 2, of their significance and of the dosimetric evaluations is given in (4). The mean dose rate to the human skeleton, due to the ^{210}Po bone content, has been assumed to be equal to the mean ^{210}Po dose rate received by the cells of the cortical bone (4,8). The yearly dose rate reported in table 2 for the adult members (smoker and non smoker) of the general italian population is in good agreement with similar data reported by the Unscear (8). The dose rate referred to spa workers and non-uranium miners should be considered purely indicative of the highest levels of exposure to radon and daughter in those environments. The ^{210}Pb-^{210}Po skeletal burden due to the radon and daughter exposure resulted to have large individual variability as a function of many factors which may seriously affect the lung retention and clearance of the radon daughter which are decaying to ^{210}Pb inside the lung (3,4). Nevertheless the reported data permit to establish the relevance of the ^{210}Po dose to the skeleton of subjects which are currently exposed or have been exposed in the past to high levels of radon and daughter in various environmental conditions.

REFERENCES

1. Blanchard, R.L., Kaufmann, E.L., Ide H.M. (1973): Health Phys. 25, 129.
2. Breuer, F., Clemente, G.F., (1979) : In: Radon Monitoring, p. 239, NEA-OECD, Paris.
3. Clemente, G.F., Renzetti, A., Santori, G. (1979): Envir. Res. 18, 120.
4. Clemente, G.F., Renzetti, A., Santori, G., and Bachvarova, A.K. (1979): CNEN Report RT/PROT (79) 6.
5. Holtzman, R.B., Spencer, H., Ilcewicz, F.H. and Kramer, L. (1977): In: Proc of the 10th Midyear Topical Symp. of Health Phys. Society, p. 245, Reusselaer Polytechnic Institute, Troy, N.Y.
6. Parfenov, Y.D. (1974): At. Energy Rev. 12, 75.
7. Spencer, H., Holtzman, R.B., Kramer, L., Ilcewicz, F.M. (1977): Radiation Res. 69,166.
8. Unscear (1977): Sources and Effects of Ionizing Radiation, p.35, United Nations, New York.