STUDIES ON THE NATURAL AND MAN-MADE RADIONUCLIDES IN THE ELEVATED RADIATION ENVIRONMENT OF KALPAKKAM

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ABSTRACT

Numerous sources of radiation (both natural and man-made) can lead to internal and external human exposures. Hence to assess the radiation dose, one requires a precise knowledge of the levels of activity of various radionuclides in different environmental matrices through which human beings are receiving the radiation dose. Kalpakkam (12° 33' N and 80° 11' E) is a major nuclear complex in the southern part of India which hosts a number of nuclear installations and where many man-made radionuclides are discharged in the environment due to routine radioactive waste releases from different nuclear installations operating at the site. Incidentally, the site is noted for the existence of elevated radiation background levels, due to the occurrence of monazite in the coastal beach sands of Kalpakkam. In light of twin aspects of the above, a study of public exposures through different environmental pathways, -especially through consumption of different dietary sources - would be worthy of a serious study.

The first aspect of the study deals with the estimation of distribution of primordial radionuclides (principally the ^{238}U and ^{232}Th series and ^{40}K) in soil, beach sand and in different types of building materials from the environs of Kalpakkam and to estimate the external dose received by the local public. The concentration of ^{238}U, ^{232}Th and ^{40}K in soil samples were 5-71, 15-776 and 200-854 Bq kg^{-1} dry respectively. In beach sand samples, ^{238}U, ^{232}Th and ^{40}K contents varied in the range of 36-258, 352-3872 and 324-405 Bq kg^{-1} dry respectively.^{137} Cs in Kalpakkam soils ranged from ≤1.0-2.8 Bq kg^{-}1 dry which was 1-3 orders of magnitude less than the concentration of primordial radionuclides in soil. The dose from outdoor terrestrial gamma radiation was calculated from the concentrations of primordial radionuclides in soil and was found to be in the range of 29-112 μ*Sv* y^{-1} with a mean of 65 μSv y^{-1}. The dose from indoor terrestrial gamma radiation was measured by keeping Thermoluminescent Dosimeter badges (TLDs) in different types of dwellings around

Kalpakkam. From the data collected from TLD badges, the mean dose was computed which was found to be 572 µSv per year.

The second aspect of the study provides information on th econcentration of^{222} Rn in different drinking water sources which ranged from 153-3836 mBq 1^{-1} The intake of ^{222}Rn through different drinking water sources has resulted in the receipt of dose of only 7 µSv y^{-1}. The computed dose received by Kalpakkam public due to radon, and its progenies via inhalation of air in dwellings was estimated to about 720 µSv y^{-1}.

The third aspect of the study gives details about the distribution of natural radionuclides, ^{226}Ra, ^{228}Ra, ^{210}Pb, ^{210}Po and $^{238+234}$u in the main dietary sources of such as cereals, pulses, vegetables, dietary sources of terrestrial animal origin (chicken, egg, goat meat and milk), marine dietary sources (crab, fish, prawn etc.), salt, drinking water, beverages etc. constituting the terrestrial and marine aquatic food pathways. The activity concentrations of natural radionuclides ^{226}Ra,^{228} Ra,^{210} Pb,^{210}Po and uranium isotopes ranged very widely from ≤ 0.2-122641 mBq kg^{-1}/ mBq l^{-1} in all the samples. The observed activity concentrations of radionuclides in the above matrices were in the following order: ^{210}Po > ^{210}Pb > ^{228}Ra > ^{226}Ra > $^{234+238}$U. It was observed that ^{228}Ra/^{226}Ra ratios were above unity ranging from 1.1 to 9.3 in all the dietary sources studied. In general, the ratio^{210}Po/ ^{210}Pb was less than unity in drinking water samples and in most of the dietary items such as ragi, wheat, pulses, vegetables, milk, goat meat, chicken etc. However, in food of aquatic animal origin such as fish, prawn and crab ^{210}Po/^{210}Pb ratios were higher than 1.0 indicating higher accumulation of unsupported ^{210}Po by these dietary sources.

Transfer Factors (TFs) of ^{226}Ra, ^{228}Ra, ^{210}Pb and ^{210}Po in different dietary sources wrt soil and water were computed. TFs of both ^{226}Ra and ^{228}Ra for the terrestrial dietary ranged from (0.02-14.1) * 10^{-3} indicating that plants did not preferentially select radium from the soil, even though radium was chemically similar to calcium, an essential element for the plants. TFs of ^{210}Pb and ^{210}Po for rice, ragi and vegetables ranged between (2.4-62.0) * 10^{-3}. TFs of ^{226}Ra, ^{228}Ra and Pb for aquatic dietary sources studied (ie. Seacrab, fresh water fish, marine fish, and prawn) ranged between 10 and 300, whereas significantly higher TFs of ^{210}Po were obtained which ranged from 1000-77000.

The computed annual effective dose received by an individual member of Kalpakkam public due to ingestion of primordial radionuclides was 898 µSv, out of which ingestion of ^{210}Po via dietary sources and drinking water alone contributed about 815 µSv. It is evident from the present study that the foods of aquatic animal origin delivered significantly higher dose to the public compared to foods of terrestrial animal origin.

The fourth aspect of the study included the estimation of content of ^{40}K in different dietary sources and computation of internal dose due to the presence of ^{40}K in the body. The study revealed that ^{40}K content in dietary sources was found to vary from 0.06 to 362 Bq kg^{-1}/ Bq l^{-1}. Since, potassium intake in the body is homeostatically controlled, the annual internal dose received by human body due to ^{40}K was measured using a wholebody monitor which was found to be 150 µSv to the public at Kalpakkam.

The fifth aspect of the study comprised the distribution of some of the important reactor released radionuclides and to derive the doses contributed to the members of the public, due to the releases of these radionuclides in the environment and to study the overall radiological impact of operation of Madras Atomic Power Station (MAPS) to the general public.

Atmospheric tritium was found to vary widely between ≤0.2 -163.3 Bq m $^{-3}$ at the Fence Post and decreased with increase in distance from MAPS site. Similarly, ^{3}H content in water ranged between 1 and 117 Bq 1^{-1} in zone-l(1.6-5 km distance from MAPS) and decreased with increase of distance from MAPS site. ^{137}Cs and ^{90}Sr activities in different dietary sources varied in the range of 23-3446 and ≤23-1028 mBq kg^{-1} fresh respectively. External dose estimates due to the release of ^{41}Ar in the Kalpakkam environment was computed using site-specific meteorological data and the annual ^{41}Ar stack release data. Total annual dose received by the members of the public at Kalpakkam was evaluated by adding external gamma dose due to ^{41}Ar and internal dose due to tritium. It was observed that the total dose at the Fence Post ranged from 21.7-30.0 µSv y^{-1} which was only 8.0-11.1 % of the annual dose limit of 270 µSv y^{-1} apportioned to MAPS operations and 2.0-3.0 % of annual dose limit of 1000 µSv y^{-1} (ie. 1.0 mSv y^{-1}) set by Atomic Energy Regulatory Board in India.

It can be concluded from the present study that the effective dose received by an individual member of the public residing at the Fence Post due to natural sources and reactor-released sources was 2451 and 41 µSv y^{-1} respectively. The study also reveled that the village Keelankalani (located at 2.1 km in NNW direction) received the maximum reactor-released dose of 22.4 µSv and the lowest dose of 2.4 µSv was received by the residents at Sadras village (located at 4.0 km in SSW direction).