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Gross beta activities and Beryllium-7 concentrations in surface air

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ABSTRACT

Background: Measurement of gross beta activities and cosmogenic Beryllium-7 concentrations were made each week during year 2002 from samples of atmospheric aerosols filtered from the air at Tehran Nuclear Research Center.

Materials and Methods: The aerosol samples were collected weekly with high-volume air sampler at the Nuclear Research Center meteorological station in Tehran (40° 35' N). The ^{7}Be contents of samples were determined with semiconductor gamma spectrometry. The long-lived beta activity, i.e. total beta activity measured four days after the end of sampling (after decay of ^{220}Rn progeny and short-lived ^{220}Rn progeny), was assessed with an automatic beta analyzer. The long-lived beta activity consists mainly of ^{210}Bi, the daughter nuclide of ^{210}Pb, as the amount of artificial radionuclides in the air is negligible.

Results: The air concentrations of both the ^{7}Be and the long-lived beta activity displayed a lognormal distribution during the study period 2002. The arithmetic mean of annual concentrations of ^{7}Be and ^{210}Pb was 6.30 and 0.50 mBqm^{-3}, respectively .

Conclusion: Despite the different origins, the concentrations of both the ^{7}Be and the long–lived beta activities are partially correlated. Both have maximum concentrations during warm mid-year months. *Iran. J. Radiat. Res., 2005; 2 (4): 211-213*

Keywords: *Beryllium-7 concentrations, gross beta activity, gamma spectrometry, lead-210.*

INTRODUCTION

The Earth's upper atmosphere is continuously affected by energetic charged particles, mainly electrons, protons and alpha particles. Most of this cosmic radiation comes from sources outside the solar system, but sun also contributes to this particle flux (Ritz 1993). In addition to ions and radicals, the cosmic rays also produce radionuclides (cosmogenic) in the upper troposphere and stratosphere by inducing nuclear reaction in atmospheric oxygen and nitrogen atoms. One of the most abundant cosmogenic radionuclides is ^{7}Be ($t_{1/2}$ = 53d). About 75% of ^{7}Be is produced in the stratosphere and 25% in upper troposphere (Johnson and Viezee 1981). Once ^{7}Be is formed in the troposphere it rapidly associates primarily with sub micron sized aerosol particles. ^{7}Be in these aerosols may subsequently enter the marine as well as terrestrial and vegetation environment via wet or dry deposition events (Papastefenou 1994).

Compared to ^{7}Be airborne, lead-210 has a totally different source. It is formed in the atmosphere from radioactive noble gas Radon-222, a decay product of Uranium-238, emanating from soil. High ^{210}Pb concentrations are formed in continental air masses since ^{222}Rn sources at sea are practically none existing. No increase of ^{210}Pb concentrations in surface air due to anthropogenic sources has been found. In this paper we report one year of continuous measurements of gross β activity and ^{7}Be in surface air. Using these data, we perceive the variation of gross β and ^{7}Be concentration in Tehran.

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MATERIALS AND METHODS

The long-lived beta activity, i.e. total beta activity was assessed with an automatic beta analyzer (Nuclear Enterprises), four days after the end of sampling, when short-lived ^{222}Rn progeny had decay into ^{210}Pb. Since the levels of radioactivity encountered in environmental samples are low, long counting times were necessary, on the order of 30000 second. The background of detector was determined before and after use by 30000 second and was subtracted from sample counts. All the calculations have been made using the appropriate density thickness corrections for efficiency to correct gross beta (based on ^{90}Sr) measurement to specific activity in Bqm^{-3} with estimated error at ± 1 sigma.

The measurement of ^{7}Be in each sample was carried out by non –destructive gamma- ray spectrometry by means of its 477.6 keV gamma-ray using a hyper-pure Germanium (HPGe) detector made by CANBERRA (relative efficiency about 20% to the efficiency of 3×3 NaI at 25cm distance; resolution 2 keV for 1332 keV gamma-ray of ^{60}Co) connected to a 4096 channel pulsed height analyzer. The counting efficiencies of the HPGe detector were measured by using a standard sample containing known amount of radioisotopes such as ^{133}Ba, ^{137}Cs and ^{60}Co. Counting time for each sample was 6ok seconds leading to the detection limit about 0.8 Bq per sample.

Figure 1 shows the spectrum of ^{7}Be in surface air. The ^{7}Be concentration was calculated using a 53 day half-life, gamma counting efficiencies of 1.2% and branching ratios of 0.11. The concentrations were corrected for decay to the mid-collection period.

RESULTS AND DISCUSSION

Monthly concentrations of gross beta activities and ^{7}Be in the surface air during the study period (2002) are presented in figures 2 and 3. The data shows seasonal variations in the concentrations of gross beta activities and ^{7}Be.

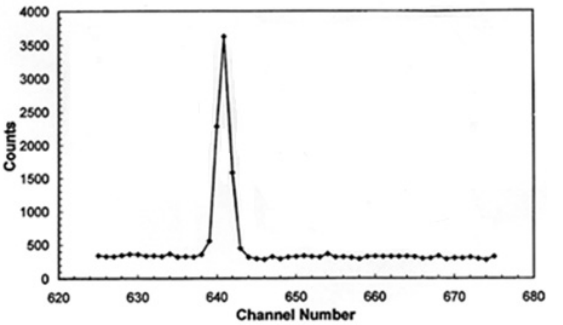


Figure1. Spectrum of ^{7}Be in surface air.

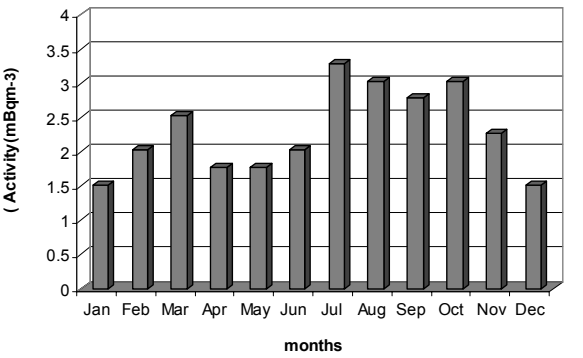


Figure 2. Monthly concentrations of long-lived beta activity in the surface air in Tehran station during 2002.

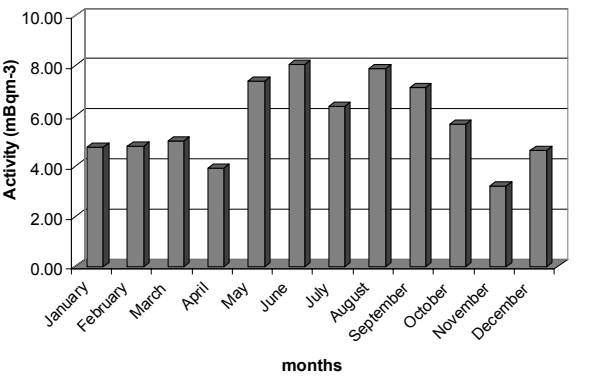


Figure 3. Monthly variations in the concentrations of ^{7}Be in the surface air in Tehran station during 2002.

Which was highest during the warm mid-year months. Such seasonal variation has long been known to occur (Duenas *et al*. 1994). Despite the different origins, the concentration of both the ^{7}Be and gross beta are partially correlated. Both have maximum concentrations during the warm mid-year months.

An important factor in producing peak concentrations of ^{7}Be during the warmer month

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is the increased rates of vertical transport of air between the stratosphere and the troposphere that occurs during the warm seasons. During the warm months, the solar heating of the surface of the earth leads to the heating of the air in contact with the surface. Cooler air sinks, displacing the warm, less dense air and forcing it upward. This new air is heated in turn and is forced upward. A convective circulation is produced, carrying surface air upward and bringing downward air from higher levels. This vertical transport carries down to the surface layer the ^{7}Be that has been produced within the upper troposphere, as well as that which has entered the troposphere from the stratosphere. Although this influence is clearly real, other factors are also important (Feely *et al.* 1988).

Plots of the frequency distribution show highly skewed (flat on the right) histograms for beta and a symmetric one for ^{7}Be (figures 4-5).

The arithmetic mean of annual concentration of ^{7}Be and long-lived beta activity was about 6.0 and 0.5 mBqm^{-3}, respectively.

In conclusion the data shows seasonal variations in the concentrations of gross beta activities and ^{7}Be. Despite the different origins, the concentration of both the ^{7}Be and gross beta

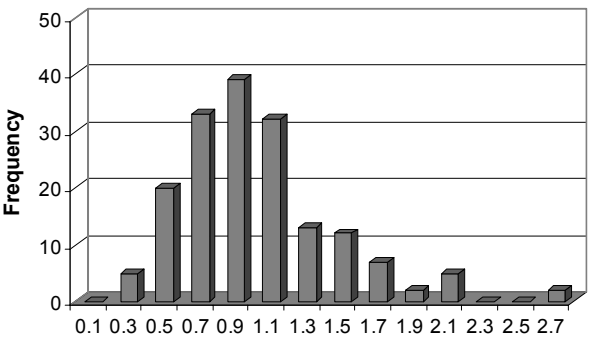


Figure 4. Frequency of gross beta activity in Tehran station during 2002.

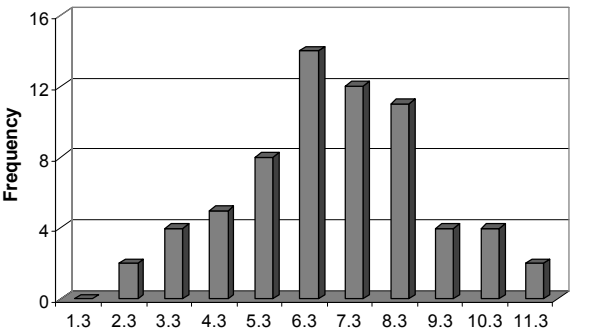


Figure 5. Frequency of ^{7}Be concentration activity in Tehran station during 2002.

are partially correlated. Both have maximum concentrations during the warm mid-year months. The lowest values of gross beta activities are registered in January while those of ^{7}Be activity came from April.

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