EVALUATION OF INHALATION RISK FROM MAN-MADE AND NATURAL SOURCES OF ATMOSPHERIC RADON

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Introduction

Nuclear power generation causes concern to the public due to the ionising radiation hazard associated with it. In fact almost all types of power generation at present, except hydroelectric power generation, cause radioactive releases into the atmosphere. Man is exposed also to natural radiation ever since his origin on earth. Of all the natural radioactivities from all the important sources to which the public is exposed, radon activity is the highest. Radon and its daughters enter the human system through inhalation which is the most important pathway compared to external radiation and ingestion. This paper deals with the different sources of atmospheric radon and the inhalation risk due to breathing air containing radon and its daughter products and compares the different sources to find out the major contributor to the internal dose to which the public is exposed. It also deals to some extent with the possible effects of breathing air containing radon and its daughter products of lower concentrations.

Sources of Radon

Table 1 gives the significant sources of radon in the atmosphere and the equilibrium activity released. The sources considered for the purpose of this paper are (a) natural, (b) coal burning, (c) natural gas burning, (d) nuclear power generation and (e) nuclear weapon tests. Average values of the equilibrium activity released have been calculated assuming that the present rate of release into the atmosphere is maintained. Technological advancement might reduce or increase the activity levels in future.

Table-1. Equilibrium Activity of Radon Released into the Atmosphere from Different Sources at the Present Level

Source	Activity in Ci
Natural	3.329×10^7
Natural gas burning	9.726×10^2
Nuclear power generation	7.795×10^2
Coal burning	3.515×10^2
Nuclear weapon testing	0.396×10^2

The important natural sources of radon considered include emanations from the soil (1) and oceans (2) and radon released when ground water and sub-surface water carrying dissolved radon become warmed at the surface (2). The release of radon from volcanic erruptions is estimated to be of minor importance from a global perspective (3).

The world production rate of natural gas is at 1.278×10^{15} l/y (4). The average radon concentration in natural gas is taken to be 50 p Ci/l (5). Radon in natural gas is released into the atmosphere when the gas is used as a fuel for power production and in chemical industries (6) and in houses (5).

Assuming a load factor of 0.6, the world nuclear energy production works out to be 86.6 GW(e) in 1981 (7). Taking into consideration the radon levels released

due to operations in the uranium mines and mills and from the tailings area (8), the equilibrium activity has been found to be 7.795×10^2 Ci.

Radon released due to power generation from coal burning includes both the radon concentration in coal and the radon emission due to coal mining which is 1000 times higher than radon trapped in coal (9).

Between 1972 and 1981, the natural uranium supply for nuclear weapon production is estimated to be 864 tons per annum (9). This corresponds to a release of radon whose equilibrium activity is 0.396×10^2 Ci. Estimation of the activity released takes into consideration the uranium mining and milling operations and emanations from tailings area (8).

Risk Evaluation

Inhalation of radon alone does not result in any appreciable dose to the lung. Normally radon can be expected to be in equilibrium with its short-lived daughters, Ra-A, Ra-B, Ra-C and Ra-C' which contribute to the radiation dose delivered to the T-B region of the lung. Assessment of dose to this region of the lung from deposition of radon daughters present in the atmosphere depends on their attachment to aerosol particles and the nature of these particles. The different parameters involved in the dose assessment for a uranium mine atmosphere are described in detail elsewhere (10). The mean particle size and the hygroscopicity of the particle which are the most important criteria deciding the activity to dose conversion factor in the assessment of dose are the same for the free atmosphere also. The unattached fraction in the free atmosphere works out to be 5% since the average aerosol concentration is assumed to be 1.5×10^4 per cm^3(11). On this basis, the activity to dose conversion factor for breathing of atmospheric air containing radon and its decay products is estimated to be 41 μrad per pCi hr per litre. This factor is used to calculate the dose rate due to radon released from different sources described earlier and to compare them.

Risk Comparison

Assuming the half-depth for radon concentration in the atmospheric air to be 1 km (12), the surface volume of the atmosphere for obtaining the surface concentration of atmospheric radon from different sources is found to be 5.1×10^{17} m^3. Then the average radon concentrations breathed by the population over the globe due to releases from natural emanation, natural gas burning, nuclear power generation, coal burning and nuclear weapon production work out to be 65.3, 190.7×10^{-5}, 152.8×10^{-5}, 69.0×10^{-5} and 77.7×10^{-6} in pCi/m^3 respectively. The corresponding dose rates due to inhalation of radon daughter products are 2.6, 7.8×10^{-5}, 6.3×10^{-5}, 2.8×10^{-5} and 3.2×10^{-6} in $\mu r/hr$. At the present level of releases of radon from man-made sources, the inhalation dose rate to the T-B region of the lung, in all, amounts to about 0.007% of the corresponding dose rate from natural sources.

Conclusions

The present study of the estimation of dose rates to the T-B region of the lung from radon and its daughters released to the atmosphere from different sources shows that the contribution from man-made sources is negligibly small compared to the inhalation dose received by man from natural sources to which he is subjected for a very long time.

Next to the release from natural gas burning, the release from nuclear power generation is the highest due to the use of natural and enriched uranium as fuel in the reactors. The fact that the total installed capacity in MW(e) from breeder reactors can grow to many hundreds of thousands (13), shows that the dose equivalent from radon release can be made negligibly small in the case of nuclear power generation.

We feel the paper will not be complete without a remark on the effects of low-level radiations on man. The theories and experimental results of the beneficial and harmful effects of ionising radiations are quite controversial and are not clear at present. Any argument leading to either of the effects is not correct without taking the synergestic effects of ionising radiation and chemical agents. There appears to be sufficient reason to think that ionising radiation alone may have beneficial effects but in the presence of certain chemical agents, the effect may be harmful. This aspect needs a rigorous study.

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