GREEN BELT TO REDUCE CONSEQUENCES OF REACTOR ACCIDENTS

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ABSTRACT

Airborne particulate activity has high deposition velocity on grass and crops. Green trees provide very high surface area per unit volume of space. A green belt, made up of optimally spaced and selected variety of evergreen trees, can, therefore, be utilized to reduce consequences of accidents in nuclear power plants, when release of radioactive materials is at ground level. Consequences of reactor accidents giving rise to ground level release in presence of a green belt in public domain are reduced by orders of magnitude. This may help reducing magnitude of emergency preparedness planning in public domain.

INTRODUCTION

Society and individuals are subjected to a variety of risks, both natural and technological. High probability-low consequence events do not attract as much public attention as low probability-high consequence events. Since it is difficult to modify probability of natural low frequency-high consequence events, society and individuals adopt various means of reducing consequences of these events such as construction of dams for reducing consequences of floods (1). Reduction of probability of high consequence events of man-made hazards such as in commercial aviation and nuclear power industry is achieved through engineering innovations. Nevertheless low probability-high consequence events in nuclear power industry have attracted special attention of individuals and society. A green belt around a nuclear power plant substantially reduces quantity of particulate radioactive material reaching public domain. Radiation exposure to population and early and continued mortalities for a hypothetical accident resulting in large, cold, ground level release of radionuclides for a light water reactor of 1000 MWe output shows fatality upto 13 km without green belt. This distance reduces to 2 km with a green belt.

ATTENUATION MODEL FOR GREEN BELT

Pollution attenuation factor, A_f of a green belt for ground level release is given by Kapoor and Gupta (2) :

$$A_f = \frac{F_D(X_1 + X_2)}{F_D(X_1)[\mathrm{erf}\{h_e/\sqrt{2}\sigma_z(X_1)\}e^{-\lambda X_2} + \mathrm{erfc}\{h_e/\sqrt{2}\sigma_z(X_1)\}F_D(X_2)]} \quad \text{-----(1)}$$

Schematic of a green belt of height h and width X_2 at a distance X_1 from nuclear power plant is shown in Fig. 1. Effective height h_e, and pollution attenuation coefficient λ are obtained from reference (2), $\sigma_z(X_1)$ is computed using relationship given by Hosker (3) and F_D is obtained from reference (4). V_d for particulate radionuclides is $0.01 ms^{-1}$ and zero for noble gases. A_f are computed using Eq.(1) for 0.7, 1.0 and 1.5 Km wide

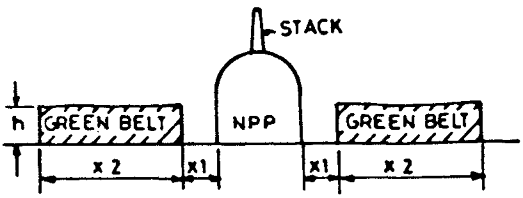

Fig.1 Schematic of a green belt around a nuclear power plant.

green belt of height 15 m consisting of pine trees planted at 50 m away from nuclear power plant(5).

DOSE EVALUATION FROM ATMOSPHERIC RELEASES

Released radionuclides, their inventory in reactor core and release fractions are taken as maximum of all release categories of light water reactor accidents (6). These are divided into volatiles and solids and noble gases due to their characteristic deposition velocities. Radioactive plume, emerging out of containment is dispersed by atmospheric turbulence and is carried away from site by wind. Given a reactor site and an accident starting time, which in turn specify atmospheric stability category and wind speed, concentrations of released radioactivity are calculated at the midpoint of chosen spatial interval and are assumed to be uniform within the interval. Buildings and structures of nuclear power plant would produce increased turbulence in near vicinity giving time integrated concentration χ as follows:

$$\chi = \frac{Q}{(1.5\sqrt{2\pi}\,\sigma_y\,\sigma_z + c.A)\,\overline{U}} \qquad \text{-------- (2)}$$

Q is source term, $\overline{U}$ is mean wind speed and σ_y and σ_z are calculated using reference (3) for z_o = 0.01 m. Vertical spread of plume is limited by the height of mixing layer L. c and A are assumed to be 0.5 and 2500 m^2 respectively. Plume gets depleted due to (i) radioactive decay of radionuclides and (ii) ground deposition. Plume depletion due to radioactive decay is considered only for decay of the parent nuclide and its depletion due to ground deposition is calculated using reference (4).

EXPOSURE PATHWAYS AND CALCULATION OF DOSES

Methodology of WASH-1400 (6) for assessment of doses to various body organs is used considering exposures through external exposure due to plume; internal exposure due to inhaled radionuclides and external exposure due to contaminated ground. Doses are calculated for all the 54 radionuclides individually and are added for each of the three pathways for bone marrow, GI tract, lung and thyroid using scheme of reference(6).

Green belt around nuclear power plant modifies concentration of released particulate radionuclides. Modified concentration χ_m for distances beyond green belt is obtained by dividing χ by A_f. Doses in presence of green belt around nuclear power plant are obtained using modified concentration χ_m for particulate radionuclides. Green belt does not modify

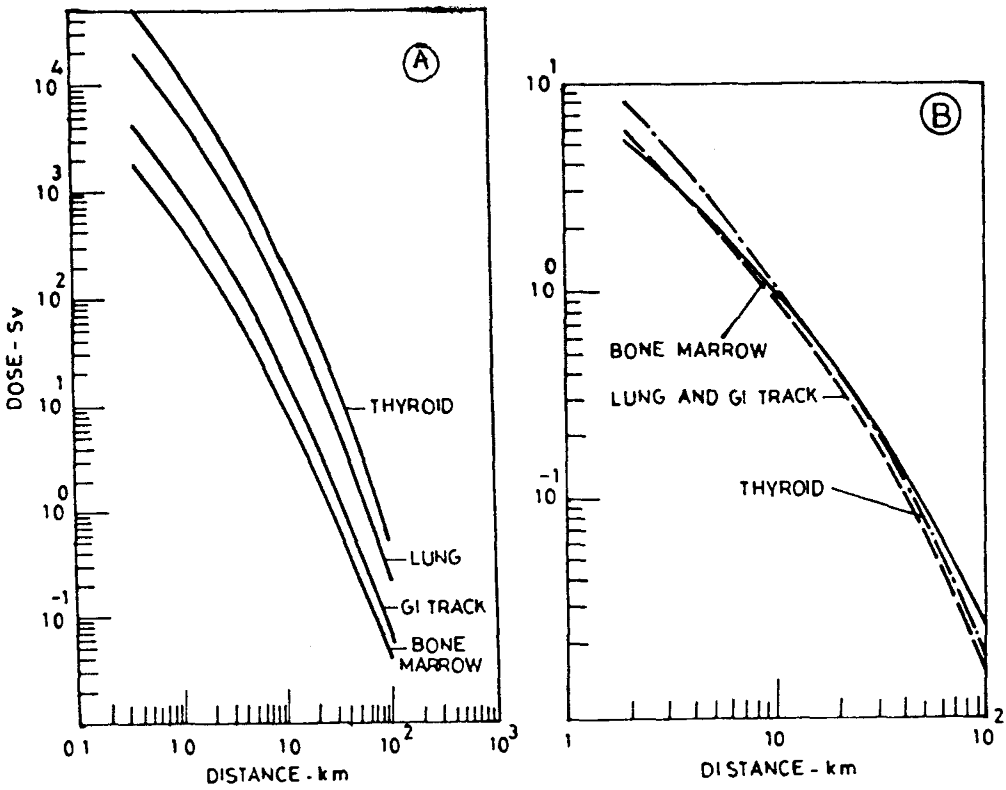

Fig.2 : Organ doses versus distance from nuclear power plant for stability category F (A-Without green belt, B- with green belt).

χ for fission product noble gases as $V_d = 0$. Calculations are performed for all six stability categories. Results are presented for category F.

RESULTS AND DISCUSSION

Variation of doses without and with green belt of width 1.5 Km to bone marrow, lung, GI tract and thyroid with distance for stability category F is presented in figures 2 A and B respectively. The reduction factor of dose to bone marrow, obtained by comparing figures 2 A and B, is 40 at 2.0 km distance. This is less than A_f since only particulate radionuclides are attenuated by green belt. Radiation exposure to bone marrow is the dominant risk of mortality. Impact of green belt on early and continued mortalities due to bone marrow exposure is presented in figure 3, where variation of mortality probability with distance from nuclear power plant for atmospheric stability category F, without and with green belt of width 1.5 Km is presented. It is seen that mortality probability is one upto a distance of about 12 km without green belt and is about 0.5 at 2 Km and at 3 km it is almost zero with green belt around nuclear power plant.

CONCLUDING REMARKS

Benefits of developing a suitability designed green belt around nuclear power plants are: