Chapter-8

Summary and Recommendations

Once radionuclides are released to the environment they can impart negative effects to the living beings. The effects can be assessed by predictive calculations and modelling for environment of operating sources like nuclear facilities. Before any kind of modelling implementation quantification of radionuclides present in different matrices and their transfer factors are required. It is essential to have site-specific risk assessment studies for long-term planning and management. The data generated in this work for proposed nuclear power plant site have been used to predict radiological dose from different matrices to the population of the area. This chapter comprises the summary of observations and conclusions derived from the laboratory investigations performed to meet the objectives of the study. Based on the findings of the study, some recommendations are made. The salient observations of the study are:

- The review of literature revealed that radionuclides concentration in various environmental matrices and their transfer factor from soil to crop are region and time specific. The observation of one particular area may not be applicable for other area due to variation in climate and soil properties. Similar variation also occurs with time span of a year, decade or century. This emphasizes the need to undertake such studies in restricted area and smaller time period.

- Baseline levels of radioactivity in water was assessed by detecting gross alpha and gross beta activities, total uranium concentration, radionuclide specific activities such as activity of $^{137}\text{Cs}$, $^{90}\text{Sr}$ and $^3\text{H}$ in different water samples collected from the study area. Gross alpha and gross beta activities in all the water samples were within prescribed limits given by WHO for drinking water. The risk due gross alpha activity in drinking water was lower than the maximum permissible limit ($<10^{-3}$). Uranium was detectable in 97% samples of the total analyzed water samples. The data showed that maximum carcinogenic risk due to uranium in drinking water was ten times lower than maximum permissible limit but there were some chemical hazard (LADD) from the uranium ingestion. The data showed that annual effective dose due to presence of $^{137}\text{Cs}$ and $^{90}\text{Sr}$ in water sample was negligible. The maximum carcinogenic risk due to both radionuclides was 100 times lower than maximum permissible limit. In all the samples analyzed, water bound tritium level was below detectable limit (MDL 0.5 Bq L$^{-1}$).
Baseline levels of natural and artificial radioactivity in soil were assessed by detecting activity of \(^{40}\)K, \(^{238}\)U, \(^{232}\)Th, \(^{137}\)Cs and \(^{90}\)Sr in all the soil samples. Activity of \(^{90}\)Sr was below detectable limit in all the soil samples. The order of different radionuclides activity was \(^{40}\)K > \(^{238}\)U > \(^{232}\)Th > \(^{137}\)Cs. The order of magnitude of the \(^{40}\)K activity in different soil samples was \(~10^3\) while it varied from \(10^1\) to \(~10^2\) for \(^{232}\)Th and \(^{238}\)U in the study area. The contribution of \(^{137}\)Cs activity to annual effective dose equivalent (\(~10^{-1}\) µSv y\(^{-1}\)) and outdoor excess lifetime cancer risk (\(~10^{-5}\)) from background radiation is negligibly small. The calculated dose rate from natural activity in soil samples was found equivalent to the Indian average of 64 nGy h\(^{-1}\). The values of \(H_{ex}\) and \(H_{in}\) calculated in the present study were less than the suggested criteria of unity. The average outdoor excess lifetime cancer risk due to natural radioactivity in soil samples collected from different locations was slightly less than that of the world average (0.29×10\(^{-3}\)). Therefore, the data revealed that there is no hazard from soil to the population of study area even if the soil is used as construction material.

Base line levels of natural and anthropogenic radioactivity in soil, food grains, fodder and vegetable matrices in the present scenario of proposed nuclear power plant site vicinity has been assessed. Natural radionuclides analysis of different agricultural produce commonly cultivated in the study area revealed \(^{40}\)K, \(^{226}\)Ra and \(^{232}\)Th activities detectable in most of the grain and fodder matrices. \(^{40}\)K and \(^{226}\)Ra activities were detectable in edible portion of all type of collected vegetables while \(^{232}\)Th activity was found detectable only in leafy vegetable, green mustard. Activity of \(^{90}\)Sr was below detectable limit in all the agricultural produce samples. \(^{137}\)Cs was detectable in 58% of the analysed agricultural produce samples. The maximum TF of \(^{137}\)Cs in mustard and pearl millet give an idea about use of these crops as indicator samples for future studies. Maximum transfer factor of \(^{40}\)K was observed for pearl millet and mustard grains while transfer factor of \(^{232}\)Th and \(^{238}\)U was greater in leafy vegetation samples than grains. Total cumulative annual effective dose and excess lifetime cancer risk due to presence of different radionuclides in locally grown agricultural produce were much lower than the permissible limit of 1.0 mSv y\(^{-1}\) for general public. Hence there is no carcinogenic risk by ingestion food items grown in the area. Radioactive dose analysis revealed ingestion of locally grown wheat, rice and vegetables safe for general public.

Environmental gamma radiation monitoring was carried out using µR Survey Meter and Thermo Luminescent Dosimeters. The average dose calculated by both methods...
was lower than the Indian average but higher than the world average. Gross alpha and gross beta activities were calculated in airborne particulate matter (PM2.5). It was concluded that the gross alpha and gross beta activity is more in town than that in villages. This may be attributed to the pollution levels of the different areas under study. The data showed that there was negligible carcinogenic hazard from the activity present in air.

**Recommendations:**

On the basis of findings of the study recommendations from the study are given as below:

- Most of the groundwater of the study area is safe for drinking. Natural uranium concentration in groundwater should be monitored temporally as increase in groundwater use can result in elevated concentrations of geological minerals in groundwater.
- Soil from the study area can be used for construction dwelling because radiological risk from the radioactivity of the soil is negligible.
- No significant radiological risk was observed from natural and artificial radionuclides activity in proposed nuclear power plant site vicinity as the total cumulative annual effective dose via dietary intake of locally grown wheat, rice and vegetables was within permissible safe standards for target population. Hence food grown in the study area is safe for consumption.
- The radiological dose in air is negligible hence it is safe to inhale the air in the study area.