Chapter 7

Overall Conclusions and Future Perspectives

The work presented in this thesis comprised basically of following components of environment monitoring in the areas of South-western Punjab, India:

1. Assessment of subsurface water quality on radiation and chemical aspects
2. Assessment of levels of external exposure to natural radiation
3. Assessment of levels of indoor inhalation exposure

Conclusions drawn out of the work are as following:

1. Study region has been found enriched with average uranium concentrations in subsurface water higher than recommended values of 60 μgl^{-1} by AERB and 30 μgl^{-1} by WHO respectively. A very large variation 2.8- 473.5 μgl^{-1} in the uranium concentrations has been found in analysed water samples. Average radiological risk (excess cancer risk) due to ingestion of natural uranium in drinking water at an average 4.05 $l day^{-1}$ over the average all India lifetime expectancy of 63.7 years higher than the maximum acceptable level ($1.67x10^{-4}$) as per guide lines of AERB, India. The mean of hazard quotient ($LADD/R_fD$) for uranium has also been found to be greater than 1. Chemical doses to public due to ingestion of individual elemental compositions drinking water for the region have been found within safe limit for As, Ba, Cd, Cr, and Se. For Zn and Pb however, Hazard Quotient has been calculated higher than unity. Among other chemical parameters of the water, TDS of the samples averaged at 550 mgl^{-1}, which is below the recommended limit of 600 mgl^{-1}, but ranged up to as high as 2020 mgl^{-1}. The pH of the waters samples however, varied in the safe zone 6.63-8.31.

2. Results of Gamma Spectrometry showed ^{226}Ra content to be up by 12.8 % than national average for the study region. However, ^{232}Th and ^{40}K are lower of content by 8.13 % and 7.5 % respectively.

a. In terms of radium equivalent activity, activity content of the region is within guideline limit of 370 $Bqkg^{-1}$.
b. With calculated average 64.30 $nGyh^{-1}$, average absorbed dose rate for the study region is greater than national average 56 $nGyh^{-1}$ by 14.8%.
c. The value of external hazard index (Hex) for all the soil samples was found to be less than 1.

3. Inhalation doses for radon and thoron levels in Fridkot, Ferozepur and Muktsar of South-Western region of Punjab are in lines with global approximate value of 2 mSv.

The radon concentration in soil- gas and surface radon exhalation rate varied as 1.9 – 16.4 $kBqm^{-3}$ and 7.48 – 35.88 $mBqm^{-2}s^{-1}$. Soil- gas radon concentrations and exhalation rate do not have very much relation with human health except when not abnormally high. Obtained magnitudes for the study region in the present study are absolutely normal.

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High levels of uranium values found in ground waters of this region thus, are needed to be taken care of in future. Since carcinogenic effects of uranium are well established; it becomes more imperative in the wake of pronounced number of cancer cases observed in this part of Punjab. Lung cancer has been related to the radiation dose to lung tissues due to radioactive decay products of uranium, rather than from uranium itself. Excess use of fertilisers on the cotton crops in this region can also be one of the regions.

To discuss about the reason behind uranium in subsurface water of this reason, when uranium concentration in the soil from this region has never been found significantly high; leaching of uranium from adjoining granitic Tosham region is suspected by some workers as one possible region behind elevated uranium concentration in underground water. Uranium content as high as 62 $mgkg^{-1}$ in the rock samples has been reported from Tosham. Agricultural activities may be other reason because it is known that radionuclides contained in fertilizers can leach through the soil and can reach the groundwater table as discussed in the text before. More work is

therefore needed to be done in the direction of precise identification of the source and mechanisms responsible for higher uranium concentrations in underground water applying determination of cations (Na^{+}, K^{+}, Mg^{2+},Ca^{2+}) and anions (F^{-}, Cl^{-}, SO_4^{2-}, NO_3^{-}, PO_4^{3-}) etc.

Uranium studies can be extended to estimation in locally produced crops and food samples to know the extent of contribution to radioactivity intake being made via eating route in addition to drinking water. It can be added to this discussion that elemental analysis work done in the present study is only brief and preliminary one. Since heavy metals zinc and lead have been found in higher values, a detailed work of monitoring heavy metal in water, soil and foods as well should be done.