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Determination of $^{226}\text{Ra}/^{238}\text{U}$ and $^{228}\text{Ra}/^{232}\text{Th}$ disequilibrium in surface soils from HBRA, Odisha, India and its radiological implications

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Naturally occurring radionuclides of terrestrial origin are ubiquitous in the Earth's crust. The radionuclides which are responsible for the enhanced natural background radioactivity are ^{238}U , ^{232}Th and their decay products. Therefore, it is necessary to monitor the environmental behavior of the naturally occurring radionuclides and radiation patterns in the HBRA to increase awareness with public health risks. Radiological investigations have been carried out in the eastern coastal area of Odisha, India to measure gamma dose rate and natural radionuclide concentration in selected surface soil samples. ^{238}U and ^{232}Th were measured using inductively coupled plasma mass spectrometry (ICP-MS) and high purity germanium (HPGe) gamma spectroscopy was used for ^{226}Ra , ^{228}Ra and ^{40}K . The high concentration of ^{232}Th in soil increased the absorbed dose rate in air to the maximum of 748 nGy/h. The ratios of $^{226}\text{Ra}/^{238}\text{U}$ and $^{228}\text{Ra}/^{232}\text{Th}$ in soil at radioactive secular equilibrium are 1. In this study $^{226}\text{Ra}/^{238}\text{U}$ and $^{228}\text{Ra}/^{232}\text{Th}$ ratios ranged from 2.9 to 5.6 and 0.8 to 2 respectively. The ratios of $^{228}\text{Ra}/^{232}\text{Th}$ in soil show radioactive secular equilibrium, whereas $^{226}\text{Ra}/^{238}\text{U}$ ratios are > 1 with an absolute difference 2.9. The ratios of $^{226}\text{Ra}/^{238}\text{U}$ clearly exhibiting the radioactive disequilibrium in soil. In order to understand the environmental behavior of the radionuclides, plots were performed between $^{228}\text{Ra}/^{238}\text{U}$ and $^{226}\text{Ra}/^{238}\text{U}$ (Fig 1(A)); $^{226}\text{Ra}/^{238}\text{U}$ and total labile ^{238}U (Fig 1(B)). Fig 1(A) shows strong positive correlation $R^2 = 0.90$ and Fig 1(B) shows correlation $R^2 = 0.42$. This suggests that geochemical nature of U is highly mobile or it is intensively leaching from the surface soil than ^{226}Ra . High values of $^{226}\text{Ra}/^{238}\text{U}$ disequilibrium are associated with depletion of ^{238}U . Therefore, the radioactive disequilibrium data between ^{226}Ra and ^{238}U is crucial to predict the geochemical mechanism such as the dissolution or migration of ^{238}U from surface soil. For detailed understanding of this phenomenon physico-chemical characteristics of soils has also been carried out.

Fig. 1 (A) $^{226}\text{Ra}/^{238}\text{U}$ between $^{228}\text{Ra}/^{232}\text{U}$; (B) $^{226}\text{Ra}/^{238}\text{U}$ between Total labile ^{238}U

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