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UPTAKE AND CONCENTRATION OF URANIUM IN ANIMALS AND PLANTS FROM A NATURAL RADIOACTIVE TERRESTRIAL ECOSYSTEM IN PAKISTAN

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Abstract: Radioecological survey was conducted on Miocene-Pliocene rocks of Qabool Khel area, district Bannu. Surface radioactivity ranged from 150 ± 25 to 350 ± 25 counts/sec. Animals and plants collected from the area have been found to contain uranium. Fluorimetric analyses of the grasshoppers of *Acrida* sp., larvae and adults of the butterfly *Anaphaeis aurota*, tenebroid beetles, shells of the mollusc (*Zootecus insularis*), a lizard and a spine of the porcupine *Hystrix indica* showed, 11.57, 2.77, 3.13, 3.03, 0.16, 7.67 and 4.89 ppm of uranium oxide (U_3O_8), respectively. Amongst the plants various species *viz.*, *Calligonum polygonoides*, *Calotropis procera*, *Fagonia cretica*, *Periploca aphylla*, *Peristrophe bicalyculata* and *Rhazya stricta* showed uranium oxide (U_3O_8) contents in the range of 0.03 to 1.25 ppm.

Key words: Radiocontamination, radioactivity, radioecology.

INTRODUCTION

It is well known that animals, plants and microorganisms inhabitants of natural radioactive ecosystems, as well as those exposed to accidental or experimental radioactive environments contain varying degrees of concentrations of radionuclides in their cells/tissues (Garten, 1978; Azam and Prasad, 1989; Juznic and Korun, 1989; Golab *et al.*, 1991; Hyne *et al.*, 1992; Georgescu and Danis, 1994). Radioecological and radiochemical analyses of such biological organisms are of great importance for obtaining information about the environment contamination level, underlying radioactive ore and mineral deposits (Eldridge *et al.*, 1984; Azam and Prasad, 1989; Maksimova, 1996). Besides their role as bioindicators monitoring biological organisms from the contaminated environments for possession of radioactivity is also an important field of study from public health point of view. As, radioactive elements can get entrance to humans by direct exposure to the contaminated environment and/or through a sequence of food chain (Shchalaev *et al.*, 1974; Lungeanu *et al.*, 1993; Chassard-Bouchaud, 1994), depending on amount and exposure time, hazardous effects of radioactive contaminants to human populations include, changes in somatic cells that cause cancer, mutations that affect future generations, effects on embryo and fetus and immediate radiation death (Grace *et al.*, 1980; Hall, 1984; Napolitano *et al.*, 1993).

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There are several natural radioecological areas, harbouring various animal and plant species in Pakistan. There is no information on concentration of radionuclides in these organisms. However, autoradiography of number of animals and plants collected from a radioecological area has indicated the presence of radioactivity (Jafri, 1976). The present study aims at determining the concentration of uranium in various animals and plant species from a natural radioactive terrestrial ecosystem.

MATERIALS AND METHODS

Collection and survey of animals and plants

The survey was conducted on Miocene-Pliocene Siwalik rocks of Qabool Khel area, district Bannu. Surface radioactivity of the study area was measured by a scintillation counter. Small areas of known surface radiation levels were selected for the collection of animals and plants. Animals and plants collected were kept in glass vials and paper files, respectively. No narcotizing agent/preservative was used to kill/preserve the animals. The animals were subjected to death by anaerobic condition in glass vials. The collection was brought to the laboratory as soon as possible.

Fluorimetric determination of uranium

The animal and plant specimens were washed with distilled water to remove clay and sand particles that may contain uranium. They were then dried at 110°C for 24 hours. Each animal or several of one species and different parts of a plant were ground, separately, with the help of pestle and mortar in order to get a fine powder. An amount of 0.2 to 0.3 g of powder was taken in China dishes. The samples were ignited in an electric furnace, at 450°C. The ignited samples were assayed for uranium contents by fluoremetric method, as described by Naeem and Abdullah (1984). Briefly described, this method involved leaching of samples in a mixture of HNO_3 and H_2O (1:1) at 250°C for 4 hours. The leached samples were filtered through Whatmann filter paper No.1 and the residue was washed with distilled water. The filtrate was evaporated on hot plate, till it began to dry. Then each sample was dissolved in 50 ml of 0.5N HNO_3. Ten ml of each sample was mixed with 15 ml of saturated $Al(NO_3)_3$ solution and 10 ml of ethyl-acetate. This mixture was poured in separating funnels which were shaken for five minutes in a mechanical shaker. Fifteen minutes were given for clear separation of organic phase (ethyl-acetate) from aqueous phase. One ml of organic phase was taken in clean platinum dishes, which were put under infra-red heaters in a dust free atmosphere in order to dry the organic aliquots. Then with the help of a large size pellitiser, an amount of 3.0 g of mixed carbonate flux (Na_2CO_3, 45.5%; K_2CO_3, 45.5%; NaF, 9.0%) was added in each platinum dish. The material was fused, by keeping the platinum dishes in a fusion assembly for about 15 minutes until a bubble free clear solution was obtained. After 5 minutes of gradual cooling the platinum dishes were removed from the fusion assembly and were placed in a desiccator for 30 minutes. The fluorescence of each pellet was then measured by fluorimeter. Standard of known concentration of uranium oxide (U_3O_8) was also processed, similarly, along with each analysis. The concentration of U_3O_8 in each sample, was measured by the following formula:

U_3O_8 (ppm) = X/S x A/B x C/D x Z/W

where, X = fluorimeter reading of sample; S = fluorimeter reading of standard; A = volume of extractant in ml; B = volume of aliquot of extractant in ml taken in platinum dishes; C = total volume of sample solution; D = volume of aqueous aliquot taken for extraction; Z = weight of U_3O_8 in standard pellet in μg; and W = weight of sample in grams.

RESULTS

Topography of the area

The area is located along eastern fringes of large stream basins known as Bannu basins. The study area mostly consists of low altitude, north-south trending and westerly dipping hills. Surface radioactivity of a small select area ranged from 150±25 to 350±25 counts/second (cps). Arid climate and lack of nutrient rich soil, indicated by rocky and sandy nature, are the major limiting factors of the area. Only two plant species *i.e.*, *Fagonia cretica* and *Rhazya stricta* were abundant. The other species were represented by a few scattered plants. Amongst animals besides the butterflies (*Anaphaeis aurota*) which were quite conspicuous in the area, it was difficult to trace the other animals. Some villages are situated near to the study area and cattles were observed grazing in the area and drinking underground mine water.

Concentration of Uranium in Plants

As the plants; *Fragonia cretica* and *Rhazya stricta* were abundant in the study area, they were uprooted from low (150±25 cps) and high (350±25 cps) radiation areas. The fluorimetric analyses of different parts of these plants revealed that they contained uranium. In general, parts of plants uprooted from the high radiation area contained higher concentration of uranium than the comparable parts of the same species collected from low radiation zone (Fig.1a,b). Concentrations of uranium in other plant species are shown in Fig.1c.

Concentration of uranium in animals

Concentrations of uranium in different parts or whole animal(s) are shown in Fig.1d. Highest concentration of the radionuclide was found in the grasshoppers, *Acrida* sp. Second and third in this order were found, a lizard and a spine of the porcupine, *Hystrix indica*, while very low amount of uranium was detectable in shells of mollusc, *Zootecus insularis*.

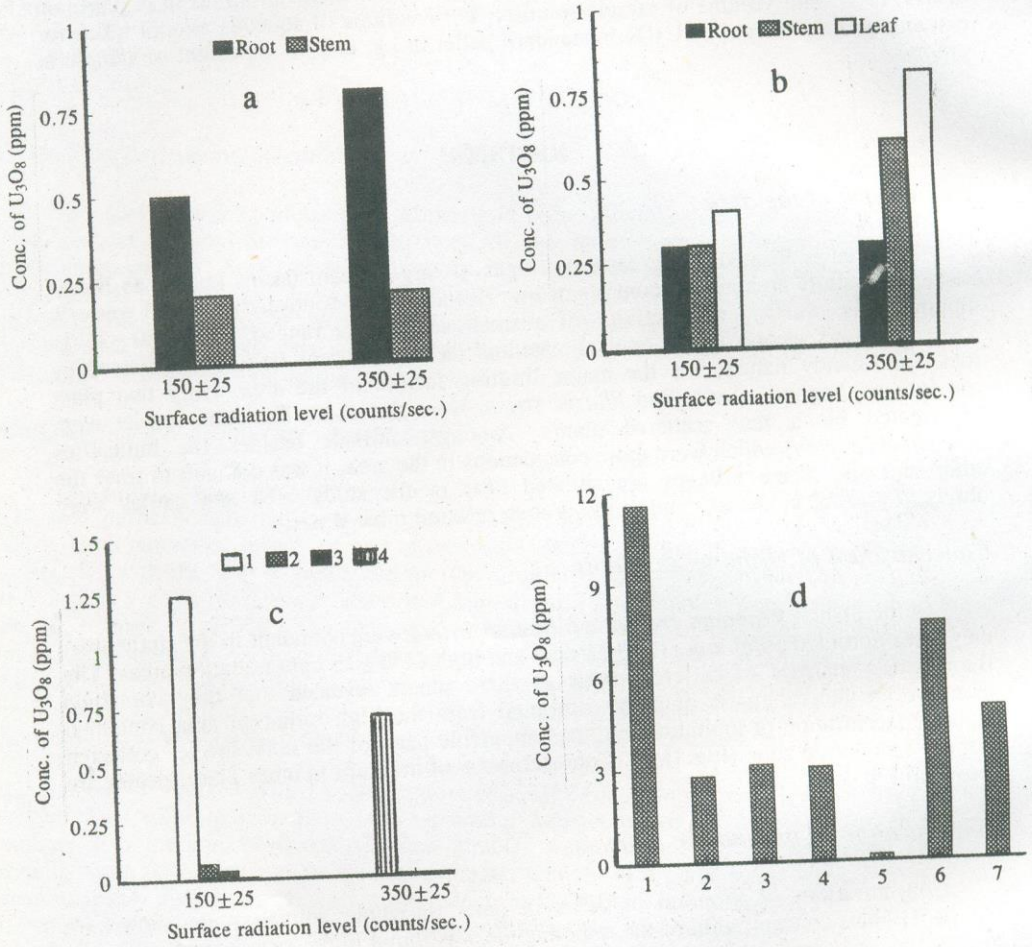

Fig. 1: Concentration of U_3O_8 in; a, different parts of *Fagonian cretica* collected from low and high radiation areas; b, in different parts of *Rhazya stricta* collected from low and high radiation areas; c, in various plants, *Calotropis procera* (1), *Peristrophe bicalyculata* (2), *Periploca aphylla* (3), and *Calligonum polygonoides* (4); and d, in grasshopper of *Acrida* sp. (1), the butterfly's, (*Anaphaeis aurota*) catterpillar (2) and adult (3), tenebroid beetle (4), shells of the mollusc, *Zootecus insularis* (5), a lizard (6) and a spine of the porcupine, *Hystrix indica* (7).

DISCUSSION

Results of this study indicate bioaccumulation and biogenic migration of uranium in animals and plants inhabitants of the area. Concentration of the radionuclide in plants appears to be proportional to the radiation level of soil. This notion has long been established that concentration of an element in a plant is in direct proportion to the concentration of that element in the substrate (Brooks, 1972). Different plant species, uprooted from same radiation area, were found to contain different concentrations of uranium. Similarly, varying levels of radionuclide were detected in different animals, even at the same trophic level. These findings support earlier studies indicating species' differences in bioconcentration of radionuclide in organisms exposed to same radioactive environment. For example, Ahsanullah and Williams (1989) exposed crab, *Pachygrapus laevimanus* and zebra winkle, *Austrocochlea constricta* to uranium (1.5-10 mg/l) in continuous-flow sea water for 40 days and have found that the crabs took up more uranium than winkles; the concentration factors were 7 to 18 and 4, respectively.

Animals (primary and secondary consumers), in general, were found to contain higher concentration of uranium than the concentration at first trophic level. Food chain transport and bioconcentration of various radioactive contaminants including uranium is well documented in literature (Jafri, 1976; Nichols and Scholz, 1989; Driver, 1994).

Further studies are needed to compare differences in genetic make up and other characteristics of such organisms with those inhabiting uncontaminated environments. Concerning potential hazardous impacts of the contamination to local human population, no risk assessment has been evaluated, at least to the knowledge of authors. The cattle observed grazing in the radiocontaminated area may easily be speculated to contain uranium. Future studies should also be extended to this direction.

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