# CHAPTER - I

## INTRODUCTION

### 1.1. THE IMPORTANCE OF PLANTS AND PLANT PRODUCTS TO MANKIND :

The average man is likely to consider himself as being superior and impressively different from the rest of the organic world, enabled by reason of his superior intellect to lead a self-sufficient and independent existence. He loses sight of the fact, or is ignorant of, that he is absolutely dependent on other organisms for his very existence and his material happiness as well. His superior intelligence has made him more dependent on others, rather than less so. Although various animal and mineral products do contribute to his welfare, it is the plant kingdom alone, that is nevertheless most essential to man's well being.

Man's dependence on plants for all the essentials of life has been of paramount importance since the human race began. Primitive man probably had few needs other than food and a little shelter. Civilization, however, has brought with it an ever-increasing complexity, and has increased man's requirements to an amazing degree.

Among other necessities of life, food is most important. An adequate food supply is, and always been man's most outstanding need. Plants manufacture the food by photosynthesis directly from the raw materials of the inorganic world for building up the plant body, or as a source of energy. The surplus is stored in highly modified organs such as underground stems, roots and seeds.[1]

## 1.2. TRACE ELEMENTS :

Normally, the terminology "trace elements" means the elements making up only a small portion of a sample with an abundance of 100 ppm. Of course it appears that there is no necessity for making this limit a rigid one. The term ultra trace may be conveniently used to designate the analysis at the parts per billion level or even smaller than this. The conotation of "trace" arose from the difficulty in past decades to analyse low concentration of some elements. The term has been retained even though many of the so called trace elements can now be easily determined.

The micro-nutrients[2] of importance to plants are copper, zinc, iron, manganese, cobalt, boron, molybdenum, chlorine and possibly vanadium. As for animals are concerned, the elements[3] iodine, selenium, chromium, tin, silicon and nickel should be added and boron omitted. Since the discovery of the new micronutrients has been a continuing process the list is probably not yet complete. Chemical analysis of plants has revealed 60 elements being present in their tissues.

Biochemical investigations reveal vitally important secrets regarding the relationship of trace elements to life processes. Recent examples are relation of cobalt to the nitrogen fixing capabilities of Leguminosae, and that of seleminium to the prevention of white muscle disease of mammals. Thus all the elements present in the cells of plants and animals may have highly significant functions in the complex processes of living organisms.[4-7] It has been proposed, therefore, that the term "functional" or "metabolism nutrient" be employed to cover any mineral element that function in metabolism, regardless of its specificity.[5]

## 1.3. ROLE OF TRACE ELEMENTS IN PLANTS AND ANIMALS:

Life depends on the maintenance of a delicate balance of numerous competing chemical and physiological processes. The trace elements are known to be of critical importance to those processes. Although their precise functions are not yet completely understood. Certain trace elements are indispensable parts of the catalytic system that speed up the metabolic activities in the cells, and some of them are structural components of enzymes and other essential substances of the body. A large number of vital processes of life depend upon the activity of enzyme system.

Trace elements play significant roles in the growth and nutrition of plants and animals. Complete satisfaction of all the mineral needs of crop is not only necessary for high yields, but so also for the development of all the powers of biosynthesis of organic compounds, and consequently, the food value of plants. Plants are the source of inorganic elements which are indispensable for most biological systems to survive. Hence, the presence of sufficient quantities of these elements in edible parts is necessary for our health. As some metals are toxic also, the effects of ultratrace levels of metals on human health are often subtle.[6,7]

The first discovery regarding the essentiality of trace elements is in the case of iron.[8] Though not a constituent of chlorophyll, iron, is indispensable for its synthesis in green plants. In its absence or deficiency, the leaf veins often become pale-green, pale-yellow or pale-white depending on the extent of deficiency. In animals also, iron is a component of the haemoglobin molecule, and a supply of this element is essential for the formation of this pigment (haemin). In both plants and animals, an adequate supply of iron expresses itself along parallel lines, chlorosis in plants and anaemic appearance in man. Symptoms of iron deficiency in plants is produced more often by high supply of calcium and also manganese, copper, zinc, cadmium, cobalt and chromium, than by absence of iron from the soil. So, too, calcium and copper affect very potently the absorption of iron by the animal. Cobalt and nickel are geochemically related to iron, and in the animal also, the three are associated with copper in connection with a number of blood conditions. Cobalt is an inseparable part of vitamin $B_{12}$ and in plants, it is closely involved in nitrogen fixation with iron, magnesium and copper. Normally, animals acquire their cobalt requirement from the plants they consume. Manganese, another trace element is an activator of some enzyme systems and improves the quality of plants, by their optimal presence, as food. For, plants receiving manganese sufficiently are richer in vitamin-C and vitamin-A than are those starved of this element.

Zinc is an essential trace element for the normal development of plants; but if present in more than trace quantities, it acts as a plant poison. Trace amount of zinc is also required by animals. Arsenic, available in trace quantity in the soil, acts as mild stimulant to plants growing thereon, a supply greater than an optimal amount is lethal to vegetation. Thus plants cannot, naturally, become toxic to animals due to this element ; the crop fails before a concentration of arsenic toxic to animals can accumulate. Boron is responsible for a large number of plant diseases both for its deficiency and toxicity. In animal tissues, though its presence is universal, till now, it is seen that it has no function there. Barium and strontium appear to be toxic to both plants and animals. Strontium is absorbed to an appreciable extent by a number of plants. This creates a potential health hazard; since $^{40}Sr$ is a harmful radio-active isotope, which, if deposited in bones of animals, may induce leukaemia.[8-10]

Some more elements are present in plants as radioisotopes of the elements uranium, thorium, cesium, rubidium etc. They play important roles in nutrition and metabolism of living organisms. The decay products of them are absorbed by the nearby molecules to change themselves into unstable isotopes leading to far-reaching biological effects such as genetic change. By way of transmutation, unwanted or harmful atoms and molecules of different kinds may be formed.[11-12] In addition to the problems arising from the generally acknowledged toxicity of heavy metals for animals, accumulation of lead, zinc and cadmium in food plants may be a factor in determining the development of human cancer.[8]

The above examples elucidate the influence of trace elements in plants or animals. The same may be either favourable or adverse. A detailed study of different aspects of the subject is useful to know their effects on animals and human beings, and thus it offers a broad field of investigation from various sides.

## 1.4. ACCUMULATION AND ABSORPTION OF TRACE ELEMENTS BY PLANTS:

The mineral nutrition of plants is available directly or indirectly from soil. The amount and number of elements present in plants may differ in various species as well as different habitats.

Various salts exist in the soil in a number of states as follows.[10]

(1) water soluble salts dissolved in the soil solution,

(2) springly soluble or insoluble salts containing exchangable ions, and

(3) insoluble substances.

These available salts are absorbed by plants through various mechanisms.[8,10] (table 1.1)

In all the mechanisms, where accumulation occurs against a concentration gradient, this constitutes active transport. The necessary energy for this is derived from solar radiation and oxidative, metabolic or chemical energy liberated

TABLE 1.1.

Some theoretical mechanisms of ion uptake by biological system.

| Mechanism | Ion Accumulation | Ion Selectivity | Principle | Probable Distribution |
|---|---|---|---|---|
| Simple Diffusion | No | No | Molecular Movement | Universal. |
| Facilitated | No | Yes | Polypeptide carrier. | Microorganisms |
| Mass flow | Yes | No | Transpi-ration | Universal in Vascular plants. |
| Contact exchange. | No | Yes ? | Ion-exchange | Roots in contact with clay particles. |
| Donnan equilibrium | Yes | Yes | Biopolymer synthesis. | Universal. |
| Redox pump | Yes | Yes | Electro-phoretic transport. | Yeast, animals. |
| Chemi-Osmosis | Yes | Yes | Charge-separation. | Mitochondria, chloroplasts. |
| Anion respiration | Yes | Yes | Cytochrome dependent | Mitochondria ? |
| Carrier complex | Yes | Yes | ATP. depen-dent protein movement. | Tonoplast ? |

by respiration. In excised roots, storage tissues, or in other conditions not involving transpirations, the source of energy for active transport must be metabolic.[8]

Soil-water supply, rainfall, hydrogen-ion concentration, organic matter content of the soil, temperature and light conditions and other environmental factors, all affects mineral intake by plants. However, characteristics of the plant and its parts effects the amount and proportions of minerals found in a food-stuff. From the same soil, two different species of plant may take and have, in their tissues, quite different proportions of various minerals. Again the individual parts of the same plant have different mineral contents.[9]

Also accumulation of any element by plants is concerned with interactions among different elements in them. In some cases, the presence or absence of one element increases the uptake of some other elements.[10]

The location of mineral nutrients in plants may be heterogenous. Roots tend to retain metals such as lead, cobalt, nickel, copper, zinc, iron, manganese, chromium and vanadium ; chloroplasts, chlorophyll bearing plastids and richer in copper, iron and magnesium, and calcium may be accumulated in mitochondria, whereas these organelles are lacking in boron. Some plants appear to extract usually large amounts of certain elements from the soil. These types of plants are referred to as "Biogeochemical indicators" and accumulator species"[8] and examples are given in table 1.2.

TABLE 1.2.

Some of the "Biogeochemical indicators" and accumulators species.

| | Element | Species | Remarks |
|---|---|---|---|
| 1. | Gold | Equisitum palustre | 60 ppm. Au in ash (?) volcanic soil of Slovakia. |
| 2. | Mercury | Holosteum umbellalum | Deposited as elemental Hg in sterile seed capsules. Volcanic soils of Bohemia. |
| 3. | Selenium | Astragalus racemosus, A. pattersonii, A. bisulcalus, A. pectinalus, Stanleya pinnata, OOnopsis spp. | Primary Se indicators restricted to seleniferous soils. Contain upon 15000 ppm in dry matter. |
| 4. | Barium | Bertholletia excelsa (Brazil nut). | 40000 ppm in nut. |
| 5. | Zinc | Thlaspi calaminare, viola tricolour | 20% Zn in ash. The calamine flora, often restricted to Zn-rich soils of Germany and Austria. |
| 6. | Cobalt | Alyssum bertolonii | Serpentine soils endemic flora upto 15000 ppm. Co. in dry matter. |
| 7. | Arsenic | Pseudotsuga menziesii. | Upto 2000 - 5000 ppm in ash of plants. |
| 8. | Boron | Chenopodiaceae, Plumbaginaceae gen. | Indicator plants. |
| 9. | Bromine. | Cucurbitaceae gen. | More than 15 ppm in some spp. |
| 10. | Radium. | Bertholletia excelsa (Brazil nut). | 1 - 2.3 $p^{Ci}/gm$. |
| 11. | Iodine | Laminaria kelp (seaweed) | First discovery of iodine. |
| 12. | Uranium | Sarcobatus sp. | 7400 ppm of ash in roots. |

Although roots are the commonly accepted principal organs for absorbing nutrients, the aerial parts, viz., stems, leaves, flowers and fruits also can, and do absorb nutrients[13-15] by simple diffusion process.

The direct contamination of plants by radioactive elements involves the deposition of air-borne materials on their aerial parts, while indirect contamination is limited to root absorption from the soil. The presence of long lived radioisotopes in soil provides their absorption into the plants from the soil. Direct contamination of radioactive elements occurs only when fallout contacts growing crops. There are also differences in the mechanisms of contamination for annual and perennial plants. Factors responsible for the rate of absorption include concentration, chemical characteristics and interrelations between the ions and $P^H$ of the rhizosphere. Radistribution of absorbed ions in the plant depend mainly on the valence of the ion in question. Bivalent and multivalent cations are much less mobile than are the monovalent cations.[16]

1.5. CIRCULATION OF MINERAL SALTS :

The circulation of mineral elements takes place in vascular tissues. Upward translocation of mineral salts from the roots to the aerial organs occurs in the xylem elements along with the transpiration stream. During their upward passage some of the mineral salts move laterally from xylem into phloem. Once the mineral salts have moved laterally from xylem to phloem they also show downward movement.

## 1.5.1. OUTWARD MOVEMENTS OF MINERAL SALTS FROM LEAVES AND OTHER LATERAL ORGANS :

The mineral salts move out of leaves in the phloem. Radioactive phosphorous ($P^{32}$) introduced as phosphate into intact leaves of squash plant moved out of such leaves into the stem but did not move out of similar leaves if petioles have been scalded.[17] Thus outward movement of salts from leaf into the stem takes place in the phloem. On entering the main vascular streams salts move primarily in a downward direction in the phloem tissues. Some lateral transport from phloem to xylem also occurs. The phloem to xylem lateral movement implies that both the tissues may be involved with the upward translocation of mineral salts moving out from the leaves. The movement of salts in phloem tissue thus occurs in both directions simultaneously in the same sieve tube or in two different sieve tubes.

## 1.6. THE FOOD CHAIN FROM SOIL TO MAN :

Radioactive contamination passes from soil and plant to man. Most of the food consumed by human beings is grown on land and except for elements like carbon and oxygen which may be obtained from the atmosphere, it is the soil that nourishes the complicated terrestrial ecosystem of which man is a part.

Radionuclides that occur naturally in soil are incorporated metabolically into plants and ultimately find their way into the bodies of animals including man. In addition to root uptake, direct deposition may occur on foliar surfaces, and when this happen the contaminants may be absorbed metabolically by the plants or may be transferred directly to animals that consume the contaminated foliage. Foliar deposition is potentially a major source of food chain contaminated both by radioactive and non-radioactive trace elements.

1.7. URANIUM AS TRACE ELEMENTS :

Uranium, the heaviest trace element in nature, is a normal constituent of all organisms, varrying generally from $10^{-4}$ percent to $10^{-9}$ percent by weight. It is a minor constituent of granitic rocks. As those rocks weathered, the uranium is oxidized to the $U^{+6}$ valance. It is highly soluble in this form. It then moves into the soil where it is reduced and precipitated.[18] It then forms oxides with silicon, nickel, cobalt, vanadium and other elements.[21] Another type of occurrence is with the marine phosphorites where grades are very low. There is a finite amount of uranium in sea water. From the soil and water they find their ways to man through food chain. It is a normal component of protoplasm.[19] It is found to be present in all plants in small but measurable amounts, the concentration being normally of the order of few ppm.[20]

Uranium is absorbed by plants through different processes as mentioned in section 1.4. It enters into the plant body by the mechanism of ion exchange rather than ion - transport. Plant families differ in regard to the amounts of various ions absorbed, because they have characteristic buffer systems resulting variations in cell sap $P^{H}$. It is available to plants in which $P^H$ of the cell sap is less than 5.2. Such saps absorb much calcium, sulphur and selenium, but small amounts of potassium. A large part of it absorbed by the plant root is precipitated within the root cell. A lesser amount is transported to the leaves and branches and is in direct proportion to the total uranium absorbed by roots.[22] The uranium contents of plants are found to have correlation with those in the corresponding soils.[23] Normally plants contain uranium from about 0.2 to 1.0 ppm, but in plants rooted in volcanised or mineralised soils, it may go up to 100 ppm or above.[8,22]

Young, in 1935, tested the beneficial effects of certain elements, including uranium, on the growth of plants. A positive result was found.[24] The toxicity of uranium to plants is moderate, but still it can result in variation of colours in flowers, presence of abnormal fruits, increase in chromosome number by nuclear stimulation and curvature in forms of plants. The radiation from internally borne uranium could be a possible cause of spontaneous mutations.[20]

Uranium concentrations in a number of plants have been estimated by different workers, with various objectives.[19,20,22,23,25-35] These include —

(1) Correlation of uranium content to the plant habitat.

(2) Assessment of mineral and geothermal resources of a region.

(3) Trace analysis of uranium in various materials.

(4) Biochemical prospecting for uranium and its effect on growth of plants.

(5) Botanical and hydrogeochemical prospecting of uranium to explore its ores. And

(6) Trace estimation of the level of uranium for the studies of radiation health hazard.

Uranium contents in plants are found to depend on ecological conditions. It occurs in higher concentrations in hydrophytes (plants growing in water or in very wet places — submerged wholly or partially or floating) than in mesophytes (plants growing under average conditions of temperature and moisture) and xerophytes (plants growing in deserts or in very dry places.)[19,20,23,25]

1.8. EFFECTS OF RADIATIONS ON MAN :

It is already known that the various corpuscular radiations and rays given out by radioactive elements produce various effects on matter. One of these effects is ionisation of the constituents of the cells and tissues of a living system which are exposed to the radiation. As a result radiation can tear off the parts of the organs, kill the cells, or render biologically active sites inactive.[36] Biological effectiveness of radiation is dependent on the mass of the incoming particles and the charge carried by them.

The effect of various doses of radiations on man wholly exposed to them for a brief (few minutes to an hour) duration manifests a number of harmful effects such as vomiting, nausea, epillation, sore throat, hemorrhage, sweating, pain, depillation, weight loss, coma, fever, burning sensation over the body, diarrhoea, acute respiratory distress, indigestion, loss of appetite, abortion, sterility, ageing, genetic change, and above all death.[37-39] Other striking changes are injury to the blood forming organs, reduces the rate at which the blood elements are produced, injury to the gastrointestinal tract and central nervous system.[40]

In addition to the effects that become apparent immediately following irradiation, some of the consequences may not appear for many years. Some of the delayed effects, such as changes in the texture or pigmentation of hair. Other effects such as cataract, leukemia or other types of cancers may appear.[41-42] Nuclear radiations and cancers are very closely related. Radiations can cause cancer, kill it and help to detect it and help in gaining an understanding of it.

Welford and Baird (1967) estimated the annual uranium dietary intake in New York, Chicago and San Francisco to be about 500 $\mu g$/year.[43-44] Based on measurements in United Kingdom, Hamilton (1972) estimated uranium content of the standard man to be 100 - 125 $\mu g$, in equilibrium with a daily intake of about 1 $\mu g$ U.[45] When the radioactive trace element uranium enters into the human body through food, it may affect the user adversely depending upon the concentration in food stuffs. Uranium isotopes are $\alpha$ emitters and may contribute significantly to the internal $\alpha$ dose delivered to human beings. It may thus have some direct or indirect effects on human metabolism.

## 1.9. SCOPE OF THE PRESENT WORK :

Traces of naturally occurring uranium is demonstrated in all substances, living and non living. This subjects all the inhabitants to a source of exposure. Such natural radioactivity to which man is exposed is thus of both terrestrial and aquatic origin. Root uptake and foliar deposition of uranium are two ways by which it contaminate crops that are eaten by man or that serve as food for animals.

Different authors have observed that the natural radioactive uranium is a normal trace element in plants, and its concentration varies from plant to plant. Intervariations among plants and intravariations among parts of the plant have been observed by a number of workers.[19,20,25,28] A quantitative understanding of the food chain transport mechanisms of uranium is required, its concentration in different food stuffs provide opportunities for studies of the possible effects of low levels of radiation exposure.

Hence in the present work, it is proposed to estimate the uranium contents in some essential plants. It may be noted in this context that U-contents in some medicinal plants of this region have already been estimated.[46-47] As such it has been proposed to select some plants which are in some ways essential for human consumption. U-distribution amongst the different parts of the plants will be studied and inter and intra-variations if any will be investigated for the plants under study. This may help towards our understanding of U-uptake and pathways by which radioactive uranium reach man. The observed concentrations of uranium in the selected materials may also provide opportunities in understanding its possible biological effects.

REFERENCES

1. Hill,A.F., (1978). Economic Botany. Tata Mc Graw-Hill Publishing Company Limited, New Delhi.

2. Nicholas, D.J.D., (1974). "The function of trace elements in plants", Trace elements in soil-plant-animal system (Nicholas, D.J.D., Egan, A.R., Eds), Academic Press, New York.

3. Underwood, E.J., (1974) "Trace elements and their physiological role in animals", (Nicholas, D.J.D., Egan, A.R., Eds), Academic Press, New York.

4. Sauchelli, V. (1969). Trace elements in Agriculture. Van Nostarnd Reinhold Company, New York, Cincinnati, Toronto, London, Melbourne.

5. Nicholas, D.J.D., (1961). Minor mineral nutrients. Annual review of plant physiology, Vol.21. pp. 63-90.

6. Lavollay, J., The world of plants. Mineral nutrition of plants. The living universe, A. Nelson.

7. Dulka, J.J., Risby, T.H. (1978). Ultratrace metals in some environmental and biological systems. Anal. Chem. 48(8) pp. 640 A.

8. Hewitt, E.J., Smith, T.A., (1975). Plant mineral nutrition. English Universities Press Ltd.

9. Nelson, A., (1951). Medical Botany E & S. Living-Stone Ltd., Edinburg.

10. Sutcliffe, J.F. (1962). Mineral salts absorption in plants. The Villafield Press, Bishopbridge Glasgow.

11. Mallette, M.F., Althouse, P.M., Clagett, G.O. (1976). Biochemistry of plants and animals, John Willey & Sons Inc., New York, London.

12. Valkovio, V., (1977). Nuclear Microanalysis, Garland Publishing Inc.

13. Tukey, H.B., Wittwer, S.H. Teubner, F.G., Long, W.G., (1955). Utilization of radioactive isotopes in resolving the effectiveness of foliar absorption of plant nutrients. Proc. of the Int. conf. on the peaceful uses of Atomic energy, Vol. 12.

14. Witt, S.H., Teubner, F.G. (1959) Foliar absorption of mineral nutrients. Ann. Rev. of plant physiology. Vol. 10, pp. 13 - 27.

15. Gabay, J.F., Dapolito, J.A., Sex, N.I. (1967) uptake of Radioactivity by vegetation as a result of soil and foliar contamination.

16. Russell, R. Scott., (1966) Entry of radioactive materials to plant. Radioactivity and Human Diet. Russell R. Scott. (ed) Pergamon Press, New York, pp. 87-104.

17. Malik, C.P., and Srivastava, A.K., (1985). Test book of plant physiology. Kalyani Publishers, New Delhi, Ludhiana, India. pp. 263 - 265.

18. Wolf, J.A., (1984). Mineral Resources — A World review. Chapman and Halt, New York. pp. 177 - 182.

19. Nagpal, M.K., Nagpaul, K.K. Bhan, A.K., (1974). Uranium in Plants, Curr. Sci. 43. No.1, pp. 8 - 9.

20. Goswami, S.C., Gulati, K.L., Nagpaul, K.K. (1977). Estimation of Uranium and Boron in plants and soil by Nuclear Etch Technique. Plant and soil, vol. 48. No.3, pp. 717 - 724.

21. Murthy, T.K.S. (1984, May). The Powerful Metal Uranium. Science To-day, pp. 44-45.

22. Cannon, H.L., Kleinhample, F.J. (1966). Botanical methods of prospecting for Uranium. Proc. Int. Conf. on peaceful uses of Atomic Energy. Vol. 6, p. 801.

23. Virk, H.S., Kaur, H. (1979). Estimation of Uranium in plants and water samples. Curr. Sci. 48. No. 7, pp. 293 - 295.

24. Stiles W., (1961). Trace elements in plants, Cambridge University Press.

25. Gulati, K.L., Nagpaul, K.K., Bukhari,S.S., (1979). Uranium, Boron, Nitrogen, Phosphorous, Potassium in leaves of Mangroves. Mahasagar, 12 No.3, pp. 183 - 186.

26. Suri, P.S., Singh, S, Virk,H.S., (1984). Uranium and Randon Estimation by Plastic Track Detectors. Ind. J. Pure and Applied Phys, Vol. 19, No.11, pp. 1131 - 1133.

27. Gulati, K.L., Goswami,S.C., Nagpaul,K.K., (1979). Mineral Elements Composition of natural vegetation and

its relation to soil of Puga Valley, Ladakh. Plant and soil, 52, pp. 345 - 351.

28. Chakarvarti, S.K., Nagpaul, K.K. (1980). Uranium trace analysis of some materials using SSNTD, Solid State Nuclear Track Detectors, (ed.) H.S. Francois et al. Pergamon Press, Oxford and New York.

29. Gulati,K.L., Oswal,M.C., Nagpaul,K.K., (1980). Assimilation of Uranium by wheat and tomato plants. Plant and soil. 55, pp. 55 - 59.

30. Virk,H.S., Suri,P.S., Singh,S., (1984). Uranium estimation in plants of Siwalik Himalayas, Himachal Pradesh, India, Private communication.

31. Singh,N, Singh,M., Singh,S., Virk,H.S., Biogeochemical Prospecting of Uranium in Lower Himalays using SSNTD. Private communication.

32. Singh,N.P., Singh,S., Singh,S., Virk,H.S. (1984). Uranium and Radon Estimation in water and plants using SSNTD. Nuclear Track and Radiation measurement, Vol.8, Nos. 1 - 4, pp. 483 - 486.

33. Singh,S., Virk,H.S., (1983), Uranium Estimation in some Indian Toothpastes. Indian Journal of Pure and Applied Physics. Vol. 21. pp. 550 - 551.

34. Singh, S., Virk,H.S., (1984). Uranium estimation in Toothpaste and Fruit Juice Using SSNTD. Nuclear tracks and Radiation measurement, Vol. 8, Nos. 1 - 4, pp.419 - 422.

35. Gamboa,I., Jacobson,I., Golzani,J.I., Espinosa,G., (1984). Uranium contents determination in commercial drinkable milk. Nuclear Tracks and Radiation measurement. Vol. 8, Nos. 1 - 4, pp. 461 - 463.

36. Jacobson, I., Gamboa,G., Moreno,A., (1984). Uranium determination in Dental ceramics. Nuclear Tracks and Radiation measurement. Vol. 8, Nos. 1 - 4, pp. 465 - 467.

37. Ramaniah,K.V., (1978). Role of Radioisotopes in Medicine. Science Gem. Vol.I, No. 5, pp. 29 - 38.

38. Loutit,J.F., (1955). The experimental animal for study of biological effects of Radiation. Proc. of the Int. Conference on peaceful uses of atomic energy. 11. pp. 3.

39. Tsuzuki,M., (1955). Early effects of nuclear injury. Proc. of Int. Conf. on peaceful uses of atomic energy. 11, pp. 128 - 129.

40. Upton,A.C., (1968). Effects of radiation on man. Ann. Rev. of Nucl. Sci. 18, pp. 495 - 528.

41. Eisenbud,M., (1973). Environmental Radioactivity. 2nd edn. Academic Press. Inc. New York.

42. Casarett,G.W., (1965). Experimental Radiation Carcinogenesis. Tumor Res. 7, 49 - 82.

43. United Nations Scientific Committee on the effects of Atomic Radiation. (1969). 24th session, suppl. No. 13 (A/7613). United Nations, New York.

44. Walford,G.A., and Baird,R., (1967). Uranium levels in human diet and biological materials. Health Phys. 13, pp. 1321 - 1324.

45. Hamilton,E.I., (1972). The concentration of uranium in man and his diet. Health phys. 22, pp. 149.

46. Baruah,M., Goswami,T.D., (1988). Uranium and Boron contents of some Medicinal Plants and their significance. Nuclear tracks. Proceedings of the fifth National Seminar on SSNTD. Calcutta. pp. 118 - 121.

47. Baruah,M., (1987). A study of the relationship between trace contents (uranium and Boron) and medicinal properties of some common medicinal plants of Assam. Ph.D. Thesis, Gauhati University.