CHAPTER I

INTRODUCTION

1.1. PLANTS AND THEIR MEDICINAL USE:

The enormous vegetation around us is a great treasury of resources to mankind. One of them is the priceless medicinal plants. Plants have been used as medicines from remote past. In India, Ayurveda, the science of life and of health, has its origin in the vedas, the oldest known classics (composed between 4500 and 1500 B.C., nearly). The Bible, the Illiad, the Odyssey, the history of Herodutus also refer medicinal uses of a great variety of plants. The earliest mention of plants and herbs as medicine is in the Rigveda. The "Sushruta" and "Charaka" Samhitas (1000 B.C.) give elaborate descriptions of materia medica. In books like "Kalpa sutranum", details of classification of drugs and medicinal plants are dealt with. Out of about two thousand items recorded in the Indian Medical Literature, less than two hundred are of mineral and animal origins; the rest is derived from plant sources. The vegetable materia medica in India has been built up in the course of centuries. Contacts with Greece and Rome, and later with Persia and Arabia provide occasional nourishments to Indian materia medica. A large number of vegetable and other plant products has come into use for treatment of diseases and are still flourishing everywhere despite the miracles of synthetic drugs.

Several thousand plants are still in use for medicinal purposes throughout the world.[1,2]

1.2. MEDICINAL PLANTS:

Medicinal properties, some genuine, some otherwise, have been attributed to a large variety of plants, numbering more than fifteen hundred, in India. All parts of the drug-plant donot always possess the same medicinal values; there are marked variations in medicinal properties of the same plant along its different parts. Again in many cases, just as one part of a plant is medicinally useful, some other part of it is poisonous or harmful.[3]

Medicinal plants are classified under various groups or headings, viz., tuberous and bulbous roots, barks of roots and of trees, leaves, flower, fruit, seeds, smell, acrid and stringent vegetables, milky plants etc. Also, there are certain norms for collection of plants. Annual plants are to be collected before ripening of fruits, biennials in the spring and perennials in the autumn, twigs in the first year of growth, roots in the cold season, leaves in the hot season and barks and woods in the rains.[4]

1.3. CHEMICAL CONSTITUENTS OF MEDICINAL PLANTS:

The medicinal plants generally owe their virtues as medicinal agents to certain active chemical substances and principles involved in them (active principles). These are seen to vary depending on the plant, its place of growth and also the season. These active principle produce definite physiological actions on the human body. They are briefly mentioned below.[4-5]

(a) AMINES AND ALKALLOIDS:

These are vegetable bases containing nitrogen and are generally decomposed products of proteins. Alkaloids, as a rule, give a bitter taste to a plant and some of the amines give a foetid odour to some weeds and poisonous characters to some mushrooms. A significant number of medicinal plants owe their curative properties to alkaloids and amines. Some of the better known alkaloids are nicotine from tobacco, morphine from poppy seeds, atropine from deadly night shade, quinine from cinchona bark etc.

(b) GLYCOSIDES:

Glycosides form a large group and are much wider in occurance than alka-loids. Many of them are non-toxic, but quite a large number of them are intensely poisonous. They generally have a bitter taste.

For example, Cyanogenetic glycosides, containing hydrocyanic acid are livestock poisons with fatal results, while saponins, another group of glycosides are poisonous to certain lower animals. In higher animals, they produce gastro-intestinal irritation, vomiting and diarrhoea.

(c) ESSENTIAL OILS:

These are pungent, aromatic compounds responsible for many of the distinctive odours and flavours of plants. These compounds have insecticidal and insect-repellant characters and, in man and livestock, they produce toxic effects by gastro-intestinal irritation.

(d) TOXALBUMINS:

This group of substances is essentially blood-poisons; but animals can be immune to them, if administered in small and increasing doses.

(e) RESINS:

These are complex substances probably derived from carbodydrates and are secreted in glands or canals and are often associated with essential oils and gums. Resins are poisonous to men and animal.

(f) ANTIBIOTICS:

The sixth group of active substances in plants are the antibiotics, which have the power to kill or arrest the development of particular species of bacteria and are nontoxic to man and all higher animals.

(g) TENINS:

These are bitter, astringent substances in the bark, wood or other parts of many plants and are useful in medicine.

1.4 POSSIBILITY OF OTHER MEDICINAL AGENTS IN PLANTS:

The isolation of the active principles from plants has felicitated a great improvement in pharmacology and helped in determining the actions of medicines in health and diseases. But chemical analyses alone do not suffice to reveal the nature of many drugs. The presence of dissociated ions, colloidal metals with an action analogous to that of ferments and of known and unknown physical properties, such as radioactivity, may also enter into the action of many drugs.[6a]

1.5. MINERAL CONTENTS OF PLANTS: MAJOR AND TRACE ELEMENTS

It is probable that almost all chemical elements are present at least in traces in some species of plants. Except carbon, hydrogen and oxygen, (carbon is taken from air, and Hydrogen and Oxygen, from water) all are available to plants as inorganic compounds from the soil, and thus, are called mineral contents of plants. Of these, the elements those help directly or indirectly in the nutrition of plants are called mineral nutrients. Some of these mineral nutrients are required in greater quantities and are called major or macro nutrients. Those required in minute or trace quantities are termed as micro-nutrients or trace elements. The status of these elements in the nutrition of plants are determined according to their functions in plants. An element is essential, if symptoms of malnutrition become visible in its absence and can be corrected only by supplying that element, and in no other way. Various elements are beneficial to the growth of many plants, and may be indispensible for some of them. For optimum growth, the essential elements must be supplied in soluble form and only at certain fairly definite concentrations. An excessive amount of one element, and particularly of a micronutrient, results in the appearance of toxicity symptoms. One element may replace another or may appear to be clearly beneficial when given at readily measurable concentrations. But no evidence of essential properties can be obtained on decrease or elimination of this element. Beneficial effects may be observed from the inclusion of an element that can only incompletely replace the physiologically essential element, which is present in sub-optimal concentration. Examples of such inter-exchangeable elements are vanadium and molybdenum, calcium and strontium, sodium or rubidium and potassium. The status of the elements in the nutrition of plants are listed in table 1.1. The abundance of trace elements (essential or beneficial) in plants may be from a few hundred parts per million (ppm) down to parts per billion (ppb) level (ultra-trace).[7-9]

1.6. FUNCTION OF TRACE ELEMENTS IN PLANTS AND ANIMALS:

Trace elements play significant roles in the growth and nutrition of plants and animals. Complete satisfaction of all the mineral needs of crops 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 also the only source of inorganic elements equally indispensable for most biological systems to survive. Hence, the presence of sufficient quantities of these elements in edible plants is necessary for our health. As some metals are toxic also, the effects of ultratrace levels of metals on human health are often very subtle.[2,9]

The first discovery regarding the essentiality of trace elements is in the case of iron.[7] Though not a constituent of chlorophyll, iron is indispensible 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 homoglobin molecule, and a supply of this element is essential for the formation of this pigment (haemin). In both plants and animals, an inadequate 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.

TABLE 1.1

The status of elements in plant nutrition

	Essential Macronutrients	Essential Micronutrients	Beneficial
Metals	Potassium	Iron	Aluminium, Strontium
	Calcium	Copper	Rubidium, Barium, Antimony,
	Magnesium	Manganese	Yttrium, Bismuth, Cadmium,
		Zinc	Tin, Lanthanum, Chromium,
		Molybdenum	Lead, Nickel, Mercury, Cuerium,
		Cobalt	Arsenic, Tungsten, Berylium,
		Vanadium	Uranium, Lithium, Thorium,
		Sodium	Titanium, Zirconium, Thallium
		Gallium	
Non-Metals	Carbon	Boron	Selenium
	Hydrogen	Silicon	Bromine
	Oxygen	Chlorine	Fluorine
	Phosphorus	Iodine	
	Sulphur		
	Nitrogen		

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 a mild stimulant to plants growing thereon, a supply greater than an optimal amount is lethel 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 dangerous radio-active isotope, which, if deposited in bones of animals, may induce leukaemia[5,10,7]

Some more elements are present in plants as radio-isotopes 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 effect such as genetic change. By way of transmutations, 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.[7]

The above examples elucidate the influence of trace elements in plants on 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.

1.7. 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 in 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) Sparingly soluble or insoluble salts containing exchangeable ions,

and

(3) insoluble substances.

These available salts are absorbed by plants through various mechanisms[7,10]:

They are :

(a) Diffusion,

(b) Mass flow,

(c) Contact exchange,

(d) Redox pump

(e) Chemi-osmosis

(f) Donnon equilibrium

(g) Anion respiration,

(h) Carrier complex.

In all the mechanisms, where accumulation occurs against a concentration gradient, this constitutes active transport and work must be done. The necessary energy for this is derived from solar radiation and oxidative, metabolic or chemical energy liberated by respiration. In excised roots, storage tissues, or in other conditions not involving transpirations, the source of energy for active transport must be metabolic.[7]

Soil-water supply, rainfall, hydrogen-ion concentration, organic matter content of the soil, temperature and light conditions and other environmental factors, all affect mineral intake by plants. However, characteristics of the plant and its parts affect 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.[5]

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 element or elements.[10]

The location of mineral nutrients in plants may be heterogeneous. Roots tend to retain metals such as lead, cobalt nickel, copper, zinc, iron, manganese, chromium and venadium; chloroplasts, chloroform bearing plastid are richer in copper, iron and magnesium, and calcium may be accumulated in michondria whereas these organelles are relatively lacking in boron. Some plants appear to extract unusually large amount of certain elements from the soil or water they grow on. They are known as bio-geochemical indicators or accumulator plants.[7]

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]

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 absorption of them from soil. Direct contamination of radioactive elements occurs only when fallout contacts growing crops. There are 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 pH of the rhizosphere. Redistributions 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]

1.8. URANIUM AS TRACE ELEMENT IN PLANTS:

Uranium, the heaviest trace element in nature, is a normal constituent of all organisms, varying, generally, from 10^{-4} percent to 10^{-9} percent by weight. It is also a normal component of protoplasm.[17] It is found to be present in all plants in small but measurable amounts, the concentration being normally of the order of a few ppm[18]. It exists in nature as oxides with silicon, nickel, cobalt, vanadium and other elements.[19]

Uranium is absorbed by plants through different processes as mentioned in section 1.7. It enters into plants 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 pH. It is easily available to plants in which pH 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 cells. A lesser amount is transported to the leaves and branches and is in direct proportion to the total uranium absorbed by roots.[20] The uranium contents of plants are found to have correlation with those in the corresponding soils.[21] Normally plants contain uranium from about 0.2 to 1.0 ppm, but in plants rooted in volcanised or mineralised soils, it may go upto 100 ppm or above.[7,20]

Young, in 1935, tested the beneficial effects of certain elements, including uranium, on the growth of plants. A positive result was found.[8] 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 chromosomes of nucleus stimulation, and curvature in forms of plants. The radiation from internally borne uranium could be a possible cause of spontaneous mututions.[18]

Uranium concentrations in a number of plants have been estimated by different workers, with various objectives. These include correlation of uranium content to the plant habitat, assessment of mineral and geothermal resources of a region, trace analysis of uranium in various materials, biochemical prospecting for uranium and its effect on growth of plants, botanical and hydrogeochemical prospecting of uranium to explore its ore, trace estimation of the level of uranium for the studies of radiation health hazard etc.[17,18, 20-33]

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 partly, 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).[17,18,21-22]

1.9. EFFECTS OF RADIATIONS ON MAN:

The various corpuscular radiations and gamma 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 radiations can tear off the parts of the organs , kill the cells, or render biologically active sites inactive.[34]

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 as development of nausea, anaemia, infection, haemorrhage, conjuctivitis, cataract, sweating, pain, depilation, weight-loss, shock, coma, fever, burning sensation over the body, skin effect leading to tumour, diarrhoea, acute respiratory distress, indigestion, loss of appetite, sore - throat, abortion, sterility, ageing, genetic change, and above all, death.[35-38] Nuclear radiations and cancer are very closely related. Radiations can cause cancer, kill it and help detect it and help in gaining an understanding of it.

When the radioactive trace element uranium enters into the human body through food or medicine, it may affect the user adversely or otherwise depending on the quantity of it. It may thus have some direct or indirect effect on human metabolism. It may be possible that, in the action of plants (and other various parts) as medicine, the uranium contents have been playing some significant role, which remains obscure so far.

1.10. BORON IN PLANTS:

Boron has been known to be an essential micronutrient for growth of higher plants and its absence, even for a short period, results in retarded cellular activity and arrested growth in plants.[40] Different plant groups and species have quantitatively different needs for boron varying over a considerable range from below 1 ppm to a few hundred ppm. The margin between boron requirement and boron toxicity in plants is often very narrow and may even overlap, so that, when plants are provided with sufficient boron for maximum growth, they may, at the same time, exhibit toxicity symptoms.[41]

The exact role of boron in plants is not fully known. The effects of its deficiency in plants are generally of quite a different kind from those produced by other micronutrient deficiencies. It is the only non-metallic essential micronutrient and does not form part of any enzyme system like other micronutrients. But it may affect the activities of a number of enzymes,[7,8] and also cellular activity, which, along with metabolic activity, is related to radiosensitivity. This infers some relation between radio-sensitivity and boron nutrition.[40] This element prevents excessive polymerisation of sugars at sites of sugar synthesis and influences calcium/potassium ratios in plants.[42]

Boron deficiency affects the young leaves of plants first and boron toxicity, the oldest.[43] It results in many diseases in plants, which are severely affected on growing point. They may die, and stems and leaves may show considerable distortion. Both the pith and epidermis of the stem may be affected giving rise to hollow and roughened stems. Leaves are often scorched and curled and may show slight mottling or some pigment formation. Fruits, when affected, are severely deformed and useless. An excess of boron has been found to hasten maturity and change of colour of fruits.[42,44]

In most plants, boron is not a readily mobile element. It reaches its greatest concentration in the leaves.[8]

An ubiquitous element, it is of considerable interest in various fields, which include semiconductors, metallurgy, coloration of diamonds, toxicity and deficiency in plants. It can have profound effects on the metallurgical properties of various alloys and it is particularly important in nuclear materials. Natural abundance of this element is low, as it undergoes thermonuclear destruction in steller interiors and hence is not a normal product of steller nucleosynthesis.[45,]

Boron has been estimated in a variety of substances including water, rocks and mineral, natural and man-made diamonds, glass, metals, some biological samples in addition to plants and soil.[18,22,24,46-51] Though its essentiality or beneficiality in animal is not yet found to exist, this element has found extensive importance in locating brain tumour in neutron therapy due to its very large capacity of absorbing thermal neutrons.[52]

Presence of boron is very important for agricultural crops and plants, as an essential micronutrient. Its low content stimulates plant growth. Its content in plant is greater than that of uranium. But when boron content of soil is of the order of about several thousand ppm, plants are opressed, deformed and subject to disease. The optimum concentration of boron for good plant growth is 20 ppm. Of course, the tolerance limits of boron for different agricultural crops and plants vary depending upon the soil type, soil moisture status, agroclimatic condition and level of nutrient.[18,22]

1.11. SCOPE OF THE PRESENT WORK:

The medicinal properties of plants and the underlying active principles taking part in the action of drugs have been a subject of extensive research in biochemistry and physiology. Basu[6a] has indicated a possible existence of some undiscovered physical principles like radioactivity which may take part in the action of drug plants.

Different authors observes that the natural radio-active element uranium is a normal trace element in plants, and its concentration varies from plant to plant and also, in the same plant, the concentration varies from part to part.[17,18,22,25,53]

Medicinal properties also vary from plant to plant, and different parts of the same plant possess different medicinal properties.[4,6,54,55] Thus there is a possibility of existence of some unnoticed relationship between the medicinal properties and uranium concentrations of plants.

Boron, though not a radio-active element, one of its isotopes, Boron-10 can be made radio-active by bombarding it with thermal neutrons of appropriate flux. This element is of interest to many investigators. It is an essential micro-nutrient of somewhat different character from other micro-nutrients. The effects on plants due to its deficiency are generally of quite a different kind from those produced by other micronutrient deficiencies.[7,8]

Hence in this present work, it is proposed to estimate the uranium and boron contents of some plants with known medicinal properties and also to find the possible correlation-ship, if any, between these medicinal properties and the observed contents of uranium and boron in the selected plants.

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