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Fluoride is thirteenth in the order of abundance of elements the earth’s crust and it is of much concern now-a-days because of its toxicity to human beings, livestock and plants. Fluoride occurrence is ubiquitous, detectable traces occur in almost all substances (Hodge and Smith, 1977). The terms ‘fluorine’ and ‘fluoride’ are interchangeably used in the literature as generic terms (NAS, 1971). Moisson (1886) first isolated elemental fluorine. Although the detrimental effects of fluoride on plants and animals have been known for sometime, it has been considered a serious toxicant to vegetation only since the industrial expansion during and following world war II (Miller, 1993). Fluorine and fluoride occur ubiquitously in the environment and because of their wide and growing use in industrial processes, their environmental importance is increasing (WHO, 1984). Fluorine has a relative atomic mass of 19 and it is a pale yellow-green gas at room temperature. It belongs to a group of elements which include chlorine, bromine and iodine, collectively called halogens from a Greek word meaning salt-producing. By the very nature of their wide distribution, the halogen group of minerals, including fluoride, forms a natural part of our environment.

Fluoride is widespread in the earth’s crust as a natural component of soil, rocks and minerals such as cryolite, topaz, micas and hornblendes (Treshow, 1970). The greater portion of fluoride is found in the form of mineral fluorpars (Calcium fluoride, CaF₂) and large deposits of mineral cryolite (sodium aluminium fluoride, Na₃AlF₆). There are three major sources of fluorine in India, viz. fluorpars (fluorite), rock phosphates (apatite, theroapatite, triplite etc.) and phosphorites. The main fluorine-bearing areas in India are Gujarat in north-west, Chandidougri Raipur in Central India and Tamilnadu and Andhra Pradesh in the South. In Gujarat, about 2800 villages spread in districts namely Mehsana, Sabarkantha, Banaskantha, Bhavnagar, Kheda, Ahmedabad and Panchmahal are highly affected by high levels of fluoride in the drinking water. The level ranges from 1.5 to 7.0 ppm whereas the safe limit according to ISI is about 1.5 ppm (Khoshoo, 1988, Palaniappan et al, 1995). Whatever may be the primary source of fluorine, the element is ultimately dispersed in the environment and is found in the
atmosphere, in soil and in water. Accordingly, fluorides can reach the plants, animals and humans through these sources (Treshow 1970).

Fluoride levels were higher in ground water samples collected from limited areas around the aluminium factory in Hirakund, an industrial town in Orissa, India. The reason for the high fluoride concentration may be due to the haphazard disposal of rejected pot linings and seepage of waste water (Sahu et al 1998, Badapanda et al 1996). The presence of fluoride in ground water in Pushkar Valley, Rajasthan and in drinking water from 21 villages in southern Rajasthan was reported. The mean concentration of fluoride in drinking water in southern Rajasthan varied from 1.5 to 4 ppm (Datta et al 1999, Choubisa 1999). Similarly, the fluoride in water and food in selected areas of Tamilnadu, India was reported (Karthikeyan et al 1996). Rao (1997) reported the occurrence of fluoride in the ground water of the Vamsadhara river basin in India. The ground water in clayey soil contained less fluoride compared to the sandy soil. Yield of fluoride by superphosphate fertilizer to irrigation water was 0.3 mg/L. Maximum amounts of 3.4 mg F/L was recorded. An inverse relationship between fluoride and calcium and positive relationship between fluoride with Na⁺, HCO₃⁻, PO₄⁻ and Electric Conductivity were observed.

The fluoride content of drinking water, human urine and hen egg shell was measured in the Gdansk region of Poland. A positive correlation was found between the concentration of fluoride in drinking water and the concentration in urine of the inhabitants. High fluoride levels were found in egg shells collected close to phosphatic fertilizer plant. The elevated water fluoride concentrations were natural (due to high fluoride content of soil) as well as industrial origin. The elevated fluoride levels in urine may be due to higher levels in water as well as inhalation of dust particles and diet (Czarnowski et al 1994, 1997). Fluoride was estimated from ground water collected from 7000 wells distributed among the 237 in Texas, USA. Four regions were found to have high fluoride levels. Several factors contributed to elevated fluoride levels in Texas. Regional geology influenced fluoride concentrations. Western parts contained higher fluoride in water (Hudak, 1999). Ong et al (1996) investigated the effect of filtrations on water fluoride levels using available filters in UK. None of the filters removed fluoride. Fluoride dietary supplement should not be prescribed for children living in optimal
fluoride areas. The effect of fertilizer effluent in ground water in Nebraska has been reported. The fluoride concentration was low but played an important role in dental health. The fluoride concentration ranged between 0.1 to 2.6 mg/L. The individual private water system should be tested for fluoride (Gosselin et al, 1999). Gujarat State Fertilizer Corporation, Vadodara, India, generate gaseous, liquid and solid pollutants with fluoride as one of the pollutants (Patel, 1991). The status of fluoride in ground water of Gujarat has been reviewed (Marriappan et al 2000).

The presence of fluoride (0.2 to 3.2 mg/L) in the ground water of the semi arid tract of Agra has been reported. Fluoride concentrations were not correlated with EC or Na concentration of ground water (Singh et al 1987). The fluoride concentration of ground water of Vishakhapattanam was also determined. A few samples consisted of fluoride concentration up to 4 mg/L. There was a positive correlation between bicarbonate and fluoride and negative correlation between calcium and fluoride (Sarma and Rao, 1997).

Fluoride behavior in the soil plant system has been studied. The fluoride distribution in the soil profile, the pH effect etc. were reported by Gament et al (1994). An extensive contamination of agricultural land with lead, zinc and fluorine were reported. Fluorine was determined as fluoride ion. The seasonal variation in the content of fluoride in the pasture herbage (mainly grasses) was investigated. Some health problems affecting young lambs in spring have, in the past, been attributed to lead toxicity, but it is suggested that excess fluoride in the diet may contribute to these symptoms (Geeson et al, 1998). Cronin et al (2000) reviewed the bioavailability of fluoride and the risk of fluorosis in grazed pasture systems in New Zealand. Phosphatic fertilizer, volcanic ash and industrial wastes were considered as sources of fluoride. Fluoride concentration in top soils slowly increased where annual inputs through atmospheric pollution and phosphatic fertilizer exceeded losses. These authors discussed the fate of fluoride in grazed pasture systems with the aim of assessing the potential toxicity of accumulating soil fluoride. Grazing sheep and cattle obtain over 50% of their dietary fluoride from soil ingestion. These researches were undertaken to measure fluoride accumulation rates and soil fluoride dietary absorptivity for a range of intensively managed New Zealand pasture soil. Evdokimova et al (2001) reported the
presence of fluoride in the soil of the White Sea Basin. Here an aluminium factory was located. The soil became more alkaline under the influence of fluoride. Melis and Senette (1997) reported the presence of fluoride and heavy metals in agricultural soil near to smelters. Haidouti (1991) reported the distribution of fluoride in the vicinity of an alumina production plant. The fluoride concentration in the soil depends upon distance from emission source. Similar results were reported in the vicinity of aluminium smelters in Norway, increased concentration of fluoride in the soil solution could indicate that plants may take up fluoride from the soil (Arnesen et al, 1995).

The discovery of beneficial effects of fluorine on dental enamel, a few decades back, has aroused interest all over the world on the effects of fluorides on the metabolism of living organisms. Accordingly, this element has been used as a therapeutic agent in dental caries but because of its profound affinity for calcified tissues, a disease called fluorosis results if this substance is taken in excess by animals or human beings (Khoshoo, 1988). The disease is known to affect skeletal and dental tissues, notable among these are dental enamel, vertebral column, pelvic girdle and ribs. Teeth and bone are not the only parts of the body affected by fluoride, large doses or persistent intake of small amounts over a large number of years can adversely influence soft tissues as well.

Fluorosis caused by fluoride is an important public health problem in India and some other countries of the world. Its incidence has been reported in both developed and developing countries like USA, Italy, Holland, Spain, France, Germany, Switzerland, India, China, Japan and several other African and South American countries. In India occurrence of this disease is endemic to many states like Andhra Pradesh, Tamilnadu, Karnataka, Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh and even peripheral parts of Delhi (Teotia and Teotia, 1984; Samal and Naik, 1990, Saralaxmi and Rao, 1993, Wodeyar and Sreenivasan, 1996).

Fluorosis occurs in human populations of NorthGujarat, India (Barot, 1998). In Gujarat among the 19 districts, 18 districts have been reported to have excessive fluoride. Out of a total of 18569 villages in the state, 2413 are facing the problem
of excessive fluoride. Fluoride contents in the districts of Amreli, Mehsana, Banaskantha, Panchmahal and Baroda range between 2.0 and 7.0 mg/L whereas the safe limit according to ISI is about 1.5 ppm. Problems associated with fluorosis are very acute in Mehsana district. Out of 309 villages where house-to-house surveys was done, 236 villages were found to be affected with the disease of fluorosis (Vasavada, 1998). The various health problems caused by water borne fluoride in the fluorosis endemic villages of Mehsana and Banaskantha district of Gujarat, India has been investigated. The study revealed high levels of fluoride in serum samples of 500 subjects. Mottling of teeth and skeletal complications were common. Intake of fluoride caused a decrease in haemoglobin content and serum protein levels. Serum cholesterol levels were normal. Circulating levels of testosterone were decreased, but not significantly enough to indicate an effect on reproductive functions. The enhanced level of serum transaminases, which are markers for liver functions, indicated structural and functional changes in liver due to fluoride intake. Changes in serum calcium, sodium and potassium levels revealed electrolyte imbalance in fluorotic subjects, while the level of thyroid stimulating hormones and tri-iodothyronine did not vary, significant increase in thyroxin levels suggested alteration in thyroid function. Thus this study revealed some harmful effects of fluoride in the soft tissue functions of this endemic population (Michael et al, 1996). Less than 20 year of age was suffering from fluorosis and it was due to the high fluoride content in deep-bore wells in village of Mandla district, Madhya Pradesh (Chakma et al 1997). 100% calves, 65.5% buffaloes and 61.0% cattle were affected with dental fluorosis in southern Rajasthan (Choubisa 1999, 2000). Karthikeyan et al (1996) reported direct correlations between the mean fluoride level in drinking water and the percent incidence of dental fluorosis in Tamilnadu, India. Moderate to severe symptoms of fluorosis in Vishakhapatnam, Andhra Pradesh was reported by Sarma and Rao (1997). Gorrel et al (2000) discussed the role of fluoride in common oral diseases. Water born endemic fluorosis in China was also reported. A study was conducted from 34 sentinel sites in 18 counties in endemic water-born fluorosis areas of China through the years 1991 to 1992. Progress in improving water quality to control fluorosis was very slow (Teng et al 1996).
Plants take up fluorides both from the soil and air. From the soil, it is transmitted through root hair into stem and finally reaches the leaves. It has been conclusively found that plants absorb more fluoride from sand than from clayey soil and more from wet and acid soils than from dry and alkaline ones. Since phosphate fertilizer contains between 1 to 3 percent fluoride, fertilized tuber crops such as potato, beet, radish etc. assimilate more fluoride from soil than from the atmosphere. Turgid plants are more susceptible to fluoride accumulation than wilted ones. Leafy vegetables such as lettuce; cabbage and celery are especially prone to deposition of air borne fluoride mainly at their exposed areas which contain more fluoride as compared to their inner parts. Fluoride injury to vegetation commonly results from gradual accumulation of fluoride in the plant tissue over a period of time. Therefore, the duration of exposure as well as its concentration are important in determining the severity of injury (Khoshoo, 1988).

Fluoride influences plants in different ways. On roots, fluoride may induce symptoms of calcium deficit (Ramgopal et al, 1969) and growth inhibition (Navara and Jegelkova 1964). Fluoride is also known to enhance georeaction and to a lesser extent the elongation of root segment (Purohit and Sharma, 1985). Fluoride injury to leaves could be observed in many ways causing necrosis at leaf tips and margins after accumulation in these areas. Chlorosis has been regarded as a symptom of chronic foliage injury while necrosis is an indicator of acute foliage injury.

Fluoride affects the activity of most of the essential enzymes involved in respiration, carbohydrate metabolism, protein synthesis, cell wall formation, energy balance, nucleotide and nucleic acid synthesis. Fluoride acts as an enzyme inhibitor. Yang and Miller (1963a, 1963b) reported the effects of fluoride on carbohydrate metabolism, organic acids and amino acids in higher plants. The effect of fluoride on chlorophyll concentration is well documented (McNulty and Newman, 1956; Purohit and Sharma, 1985). This effect is accompanied by fluoride accumulation in chloroplast (Chang and Thompson, 1966).

It is very necessary to understand the basic mechanism involved in fluoride toxicity in plants, animals and in particular, human beings in concrete biochemical
terms, only then it would be possible to devise effective control for treatment of this crippling disease. As plants are directly or indirectly involved in causing fluorosis, it was thought of interest to study the effects of fluoride on plants.

Higher plants have been used as a source of drugs by mankind for several thousand years. With the development of modern medicines, synthetic drugs and antibiotics, the importance of plants as a raw material decreased considerably. However, plants are used as a source of some of the most important drugs, even in the modern system of medicine (Akhthar Husain, 1991). Reference to plants in 'Rigveda', 'Athervaveda', and later in the works of Charaka, Sushruta, Vagabhatta. Mahadeva, Jivaka, Bhava Mishra etc. proves that a knowledge of plants and their medicinal utility was very important from the very early days of Indian civilization and culture. Dhar et al (1987) reported that more than 75% of the plants mentioned in different reorganized pharmacopoeias of the world and almost all important medicinal plants used in Ayurveda and Siddha occur in different parts of India.

Joshi and Dhar (1987) gave an overview on Indian medicinal plants. They suggested that factor such as soil, rainfall, method of cultivation, time of collection and harvest, drying, storage etc. play an important role in the production and quality of crude drugs. Herbal drugs are playing an important role in health care programmes world wide, especially in developing countries. This is primarily due to the general belief that herbal drugs are without any side effects besides being cheap and locally available. This article gives an account of 21 medicinal plants species, which are being used, on a large scale, for treatment of particular diseases, reported to be having serious side effects. Medicinal plants, before being allowed to be used as drugs, should also be tested for side effects (Gupta and Raina, 1998).

Isabgol (Plantago ovata Forsk) is a very important cash crop in Gujarat and the number one foreign-exchange-earning medicinal plant. Husk of Isabgol separated from the seed is most important and is directly consumed by human beings for health care. Isabgol var Guj -2 is widely cultivated by farmers. The seed contains significant amounts of protein, small amounts of drying oil, a high quality mucilage,
some cellulose and traces of starch (Singh and Virmani, 1982, Indian Herbal Pharmacopoeia, 1998).

The medicinal value of Isabgol is exclusively due to the mucilage content, which consists mainly pentosans (Karawya et al, 1971). Seeds are of very cooling nature and form rich mucilage with boiling water. Seeds are used to treat inflammatory conditions of the mucous membrane and gastrointestinal and genital urinary tracts, in chronic dysentery and diarrhoea. Seeds are crushed and a paste applied to rheumatic swellings. A cooling lotion for the head is prepared from the mucilage and decoction is prescribed for coughs and cold (The Wealth of India, 1962).

Garden Cress (Lepidium sativum L) known as “Asalio“ in Gujarati is also a medicinal plant and cultivated throughout India. It is used in the treatment of asthma, coughs and bleeding piles. The seeds are used by both vaidas and hakims on account of their mucilaginous properties. The seeds of plant are rubefacient, galactagogue, emmenagogue, laxative, tonic, aphrodisiac and diuretic. They are used in poultices for pains and sprains (Kirtikar and Basu, 1993). The seed mucilage known as cress seed mucilage is used as a substitute for tragacanth and gum arabic. Leaves are consumed raw as salads, it is also cooked with vegetable curries and used as a garnish. The plant is used as fodder for horses, camels etc. (The Wealth of India, 1962). Harjit-Kaur (1998) reported the estrogenic activity of some herbal galactagogue constituents and Lepidium sativum was one of the plants examined. The physicochemical characteristic of Lepidium sativum seeds was also studied. It is traditionally used in India in the diet of the lactating woman and also recommended for diarrhea and dysentery (Mathews et al 1993). Treatment of diabetic patients with Garden Cress seeds (15 mg/day) for 21 days reduced the level of blood glucose in 9 patients out of 11. Thus, Garden Cress seeds are a potential hypoglycemic agent (Patole et al 1998). Kalmegh (Andrographis paniculata Nees) is widely distributed in tropical and sub tropical parts of India. The dried aerial parts, preferably leaves and stems are medicinally useful. It is a bitter annual herb commonly found throughout India (The Wealth of India, 1962). The plant is used as a bitter tonic. A decoction of the leaves is used in debility and dyspepsia. Whole plants are used as a drug and it is recommended in cases of various types of fevers, especially in intermittent fevers.
'sannipatinfluenza etc. It is also used in different types of skin diseases, itching, swellings, ulcers etc. It is an astringent laxative and used in cases of dysentery. It is one of the most frequently used plants in hepatoprotective polyherbal formulation in India. The medicinal property is due to the andrographolide (diterpene lactone) (Indian Herbal Pharmacopoeia, 1998).

Jamwal and Kaul (1997) collected the medicinal plant Andrographis paniculata from Jammu, Gujarat and Poona. The eight morphological characters and andrographolide content were studied. The morphological characters were not much varied between the populations. The andrographolide content was highest (2.1%) in the sample from Gujarat. Kalmegh from 10 population collected in different parts of India was compared in performance trials for two years with a view to introducing it as a short-rotation crop in fields in North West India because there is a growing demand for this plant. At present, it is commercially collected from forests and this is leading to its scarcity (Gupta and Srivastava, 1995).

The antidiarrhoeal activity of diterpenes of Andrographis paniculata against E. coli enterotoxins has been reported. Alcoholic extracts from plants exhibited significant antidiarrhoeal activity against E.coli enterotoxins in animal models. Andrographolide was most effective (Gupta et al 1990). Kalmegh is an ethenobotanical important plant. Tribals used the juice of this plant as an antidote for snakebite; leaf extracts were used to expel worms and root decoctions used for stomach pain. In ayurveda, the plant is considered as an antifebrile and antihepatotoxic drug. Today, many liver preparations contain Kalmegh extracts. Phytochemical and agrobotanical analysis of samples suggest that herbal and alkaloid yields vary with respect to the harvesting season and light level (Gupta and Srivastava, 1994). The anti-inflammatory, antipyretic, antiulcerogenic, analgesic and antiallergic activity of andrographolide has been reported by many workers. This activity was tested in rats and mice (Habtemariam, 1998, Madav et al 1995, 1996, 1998). The Hepatoprotective and cardiovascular activity of andrographolide was reported by Saraswat et al (1995) and Zhang and Tan (1997). In traditional Indian medicine Kalmegh is used to treat liver disease, dysentery, bowel problems, colic and general debility (Chander et al 1995).
Looking to the importance of Isabgoi, Garden Cress and Kalmegh, these were selected for the study. As these plants are cultivated in fluoride contaminated parts of Gujarat, it was thought of interest to study the effect of fluoride on these plants. For the study sodium fluoride (NaF) was used as a source of fluoride. The aims of this study on the effects of fluoride on growth, development and metabolism were as follows:

- To study the effect of NaF on the growth of Isabgoi, Garden Cress and Kalmegh seedlings under laboratory conditions
- To estimate the selected enzymes and metabolites in Isabgoi and Garden Cress seedlings grown with NaF under laboratory conditions
- To study the effect of soil application of NaF on growth of Isabgoi, Garden Cress and Kalmegh
- To determine the photosynthetic pigments in leaves of Isabgoi, Garden Cress and Kalmegh grown on NaF contaminated soil
- To study the effect of soil application of NaF on selected enzymes and metabolites in Isabgoi and Garden Cress
- To determine fluoride uptake by seeds and vegetative parts of Isabgoi, Garden Cress and Kalmegh grown on fluoride contaminated soil and to study the impact of fluoride on the chemical properties of soil
- To study the effect of foliar application of NaF on growth of Isabgoi and Garden Cress
- To estimate the photosynthetic pigments, selected enzymes and metabolites from the leaves of Isabgoi and Garden Cress receiving foliar spray of NaF
- To determine fluoride uptake by seeds and vegetative parts of Isabgoi and Garden Cress sprayed with NaF