Literature Review
LITERATURE REVIEW

In the beginning of 21st century, environmental issues have emerged as a major concern for the survival and welfare of mankind throughout the world. Environment is the sum of substances, forces and conditions external to the organism, it affects its various components including the organisms and constitutes a multi-dimensional system of complex relationships in a continuing state of change (Iqbal et al., 2000). Development in the form of industrialization, urbanization has resulted into environmental pollution. Environmental pollution means, the presence of one or more contaminants such as dust, fumes, gas misodour, smoke or vapour beyond a prescribed limit in the atmosphere which may be injurious to living organisms, cultural heritage etc. The factors, which are causing pollution, are called pollutants.

Air pollutants are classified in two basic categories (1) Primary air pollutants and (2) secondary air pollutants. Primary air pollutants are originated directly from sources while secondary air pollutants are formed through reactions between primary air pollutants. Primary air pollutants may be either gaseous or particulate in forms. Gaseous air pollutants are sulphur dioxide (SO₂), oxide of nitrogen (NOₓ), carbon
monoxide (CO), hydrogen fluoride (HF), ammonia (NH₃), ethylene (C₂H₆) etc. Particulate air pollutants are coal dust, cement dust, brick-kiln dust, fly ash, soil dust, suspended particulate matter (SPM) etc. The secondary air pollutants are peroxyacetyl nitrate (PAN), ozone (O₃) and acid rains (H₂SO₄ and HNO₃). During high humid conditions SO₂ and NO₂ react and fall on ground in the form of 'acid rain' (Oden, 1968).

There are numerous sources of air pollutants in nature depending upon local factors. The natural sources are pollen grains, water droplets or spray evaporation residues, wind storm dust, meteoric dusts, surface detritus and volcanic eruptions and man-made sources are industrial wastes, ventilation products from local exhausts system processes, waste discharge heat power and waste disposal by combustion process; transportation sources-motor vehicle, rail mounted vehicles, aeroplanes and vessels; agricultural activity, fertilizers, insecticides, pesticides, spraying and burning of vegetation etc.

Proper and healthy growth of the plants can be achieved only when atmosphere is free from pollutants as over 90% biomass of green plants is derived from atmosphere (Heck et al., 1987). The Environmental Protection Agency (EPA) in U.S.A. estimated that in 1976, annual losses to agriculture
production caused by poor air quality were around 2.9 billion dollars. Yield losses have been found to be caused by air pollution in various crop plants including cereals, leguminous crops, oilseed crops, vegetable crops and ornamentals. Air pollutants adversely affect plant in various ways ranging from alterations in plant physiology and biochemistry to visible symptoms of chlorosis, necrosis, early senescence, stunting etc. (Heagle, 1973). The injury and severity of disease due to pollution depend upon the type of air pollutants, their concentrations in the ambient air and exposure periods (Barrett and Benetict, 1970; Brandt and Heck, 1968a and 1968b; Darley and Middleton, 1966; Khan et al., 1997).

**Particulate Air Pollutants**

Particulate matter is a discrete mass of any material in the atmosphere that may be microscopic and submicroscopic in dimensions. The size ranges from 0.001μm to several hundred micron. Particulate matter in atmosphere from natural, as well as man-made sources are non-gaseous and ubiquitous in the atmosphere. They are generally classified in three categories as fumes, mists and dusts. Very small solid particles are carbon black, silver iodide, combustion nuclei and sea salt nuclei commonly known as fumes. Liquid particulate matters,
generally categorized as 'mists', includes rain drops, fog and sulfuric acid mist. Larger particles such as wind blown soil dust, fly ash, cement dust, brick-kiln dust, foundry dust and pulverized coal are 'dust'. Some particulate matters are biological materials, such as viruses, bacteria, bacterial spores, algae, fungal spores and pollen grains.

Natural sources of particulate matters in atmosphere are soil and rock debries (dust), volcanic emission, forest fires and reaction between natural gas emissions. Man-made sources are of four types-(i) Fuel combustion and industrial operations- mining, smelting, polishing, furnaces, textiles, pesticides, fertilizers and chemical production. (ii) Industrial fugitive processes- materials handling, loading and transfer operations (iii) Non-industrial fugitive processes-roadway dust, agricultural operations, construction fire etc. (iv) Transportation sources- vehicle exhaust and related particles from fire, clutch and break-wear.

Fine solid (smoke) or liquid (mist) particles are usually of colloidal dimension, floating in air termed as an 'aerosol'. On the basis of origin, particulate matters are classified in primary and secondary types (Clark and Whitby, 1967). Primary particulates having size about 1-20μm emanated by
various industrial or combustion processes are directly injected into the atmosphere, whereas, secondary particulates i.e. sulphates, nitrates, hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) of 0.005-several μm sized or the product of certain reactions occur in the atmosphere in the presence of sunlight.

Particulate air pollutants in the atmosphere can not be expressed in volume units and the favored unit is the microgram per cubic meter (μg/m³). The concentration of particulates in the atmosphere may vary from several hundred per cubic centimeter in ultra clean air to more than 100,000 per cubic centimeter in high polluted zones. In urban areas, the average levels of atmospheric particulate masses generally have been found to be 60μg/m³ to 220μg/m³ and levels may range upto 2000μg/m³ near the vicinity. While in remote areas this level may be as low as 10μg/m³.

The size of the particulate matters is their most important physical property. The particles having the diameter 100 to 1000μm are large dust particles and they settle rapidly. The smaller particles having size from 0.001 to 10μm come under suspended particulate matters (Sharma, 2001). They remain suspended in the atmosphere for fairly long time, which
collide with other particles in random movement and form larger particles by coagulation. Most of the particulate masses in the atmosphere occur in the size range from 0.1 to 10 μm.

The rate of fall out the particle by gravity is dependent on different factors i.e. shape of the particle, velocity, air density, particle density, wind movement, turbulence, thermal conditions and electrostatics at the surface of the particle. About 2000 million tonnes of particulate matter per year are released from natural agencies and about 450 million tonnes of particulate matter from man-made activities (Dara, 2000). Many of the suspended particulate matters originating from anthropogenic sources in cities and industrial areas, as well as from volcanoes, forest fires and nuclear explosions, notoriously have been moving freely across international borders. Yunus et al. (1996) reported that due to increased attention on air pollution reduction programs and enforcement of various Clean Air Act of the SPM emission in many industrialized countries now have decreased the level of pollution there.

**Effects of particulate air pollutants on plants**

Particulate matters when settle on leaves, stem and other parts of plants cause severe damage to the plants like
chlorosis, necrosis and death of the tissue (Darley and Middleton, 1966; Heck et al., 1970). Particulate emissions are considered more harmful to vegetation when they are highly caustic or heavy deposition occurred. Colwill et al. (1979) observed the poor growth of the plants grown along roadside with highly busy traffic due to heavy deposition of particulate matters. There are numerous reports that dust of varying origin interfere with stomatal functioning mostly by filling and blocking the stomatal aperture (Ricks and Williams, 1974; Fluckiger et al., 1978, 1979); increasing leaf temperature (Eller, 1977; Fluckiger et al. 1978); transpiration (Beasley, 1942; Eveling, 1969); reducing photosynthesis (Darley, 1966; Khan et al., 1997) and increasing the uptake of gaseous pollutants (Ricks and Williams, 1974). All these effects eventually result into poor growth of suffering plants leading to reduced yield.

Cement dust is one of the important particulate air pollutants. Chemically it is a mixture of oxide of calcium, potassium, aluminium, silica and sodium, which sets into a hard mass to contact with water. Darley (1966) reported that the cement dust is harmful to vegetation, leads considerable reduction in agricultural production, primarily affecting fertilization and starch production. As fly ash contains very
small fraction of nitrogen (0.2%) (Wong and Wong, 1986, 1989), plant growth, yield, leaf pigments and seed proteins are also affected adversely through poor nitrogen availability in fly ash amended soils. Wagner (1939, 1942) concluded that the increased transpiration rate was due to fine particles of clay, talc and silica trapped in the stomatal apertures of the wet leaves of Coleus blumes. Brick-kiln dust was reported to cause of fluoride-related crop injury. Leaves of rice plants grown in the ceramic and brick industry areas of Taiwan showed acute symptoms of tip necrosis and chronic symptoms of yellowing and mottling (Shyu et al., 1999; Sum and Su, 1985). Limestone dust deposition on the leaf surface of vegetation growing near the lime quarry affected the vegetation adversely (Berger and Glatzel, 1994). Due to the presence of calcium and limestone dust, pH values of leaf surface become high and reduces the ammonium/nitrate ratio (Berger et al. 1996; Berger & Glatzel, 1994; Dasch, 1989). The limestone dust does not form a continuous film all over the leaf surface but either trapped by trichomes on hairy surface or forms aggregates on smooth surface due to which significant detrimental effect of limestone dust on photosynthesis and transpiration takes place (Gale and Easton, 1979).
The particulate matters possess macro- and micro-nutrient elements which are found to be essential in plant nutrition. These elements are sixteen in number, out of these only seven (Fe, Cu, Zn, Mn, B, Mo & Cl) are required in smaller amount and thus they are called micro-nutrients or trace elements. On the other hand macro-nutrients are those elements which are needed in large quantities such as C, H, O, N, P, K, Ca, Mg and S. The excess and deficiency of essential elements in plant may cause several diseases as they play specific role in the life process of plant growth (Arnon, 1950). Das (1988) observed that macro-and micro-nutrients occur in particulates, act as a supplementary source of nutrition for graminaceous plants. Members of Poaceae possess copious and numerous auricular hair which absorb chemicals from the dust. Dongarra and Varrica (1998) evaluated the presence and the distribution pattern of heavy metals in air particulate matters at Volcano Island, Italy, they assessed 42 lichen samples of the spp. Parmelia for metal contents. The elements Pb, Br, Sb, As, Cu, Zn and Au appeared to be enriched in lichens with respect to local crusted material. The distribution maps of the enrichment factors followed the main wind direction. Mishra and Shukla (1986) treated plants of maize and soybean with fly ash by dusting. At the lower dusting
rates both the crops showed an increase in plant heights, dry weight, metabolic rates, but reduction occurred in pigment contents and dry matter production. Reduction in plant growth at highest dusting rate was attributed chiefly to the excessive uptake and accumulation of boron and alkalinity caused by excessive soluble salts on the leaf surface.

**Control of particulate air pollution by plants.**

Certain green plants, grasses and epiphytes like orchids could control particulate air pollution. Pollution Research Laboratory, College of Agriculture, University of Calcutta has reported that certain plants have remarkable dust filtering, air cleaning and air purifying capacities. Das (1981) reported in a study that certain plants with simple leaves such as peepal (*Ficus religiosa*), pakur (*Ficus infectoria*), banyan (*Ficus benghalensis*), teak (*Tectona grandis*), sal (*Shorea robusta*), arjuna (*Terminalia arjuna*), mast (*Polyalthia*), mango (*Mangifera indica*) etc. are better dust collectors than the plants with compound leaves like gul mohar (*Poinclana regia*), tamarind (*Tamarindus indica*), *Cassia fistula*, neem (*Azadirachta indica*). Orientation of leaf on the main axis, size, shape and surface of leaf, trichomes and their types, wax deposition, stomatal movement, venation pattern and cuticular
configuration etc. control the dust-trapping potential (Shetye and Chaphekar, 1977; Das, 1981; Yunus et al., 1985). Roadside plantation is effective in reducing the amount of particulate matter in the atmosphere as trees have ability to abate overland movement of particulate pollutants resulting in reduction of 27% by deciduous trees and 38% by coniferous stand in urban areas (Dochinger, 1980). A green patch of 2.5Km sq. reduced 27% dust fall in Hyde Park of London (Meetham, 1964).

Among the particulate air pollutants, fly ash and brick-kiln dust are two major pollutants in India. Fly ash is emitted from thermal power plant in huge quantity and brick-kiln dust from brick-kilns during combustion of coal.

**Fly Ash**

Fly ash is a major air pollutant produced by thermal power plants during coal combustion. Among the energy projects, the thermal power plants are of prime concern, which produce energy by burning coal, supply bulk of power generated in India. Consequently, thermal power plants spread all over the country are major sources to the atmospheric pollutant. In India, about 65 million tonnes of coal ash was produced during 1993. At present, nearly 90 million tonnes of
fly ash are being produced from the thermal power stations throughout India. It is likely to exceed 140 million tonnes by the year 2020 AD (Anonymous, 1997). Such removal and disposal of large amount of ash is a difficult task and posses a serious environmental and ecological problem.

**Characteristics of fly ash**

The composition of the parent coal, conditions during combustion, efficiency of emission, control devices, storage and handling of other by products and the prevailing weather conditions (Anonymous, 1997) determine the properties of fly ash. Bulk density of fly ash of British coal ashes was quite low i.e. 0.99 to 1.73 g cm⁻³ (Townsend and Hodgson, 1973) and 0.56 to 1.23 g cm⁻³ (Cope, 1962), which makes fly ash a good material for light weight block (Phung et al., 1978).

Fly ash consists of many minute, glass-like particles of 0.01 to 100 mm having specific gravities 2.1 to 2.6 (Davison et al., 1974). It gives spherical, glassy and transparent appearance due to melting of silicate minerals during coal-combustion (Hodgson and Holliday, 1966). Fly ash of Indian coal consists of 25% sand sized particles (2 to 0.02mm), 65% silt sized particles (0.02 to 0.002mm) and 10% clay sized particles (<0.002mm) (Mishra and Shukla, 1986). It contains
various useful elements such as Ca, Mg, Fe, Cu, Zn, K, Mn, B, S and P along with appreciable amounts of toxic heavy metals such as Cr, Pb, Hg, Ni, V, As, Si, Al, Mo and Ba (Majumdar and Mukharjee, 1983; Fulekar et al., 1983; Dalmau et al., 1990; Sikka et al., 1994) except nitrogen (Adriano et al., 1980). The fly ash is generally alkaline, with pH mostly ranging from 8.2 to 12.5 (Furr et al., 1977). The contents of B, Ca, Mg, Mn and Mo in plants grown on fly ash or fly ash amendments indicate that these nutrients are present in a soluble form (Cope, 1962; Hodgson and Holliday, 1966; Rees and Sidrak, 1956). Some fly ashes also exhibit Pozzolanic properties, i.e. they can react with water in the presence of lime to form cement, which can result in reduced infiltration and root penetration in ash deposits and ash amended soil (Townsend and Hodgson, 1973; Adriano et al. 1980; Bradshaw and Chadwick, 1980). Deposition of fly ash on land affects the soil properties. Soil becomes enriched with salts and trace elements, thus reduces bulk density of soil and ultimately increases pH, electrical conductivity, water holding capacity, Ca, Mg, Na, B and \( \text{SO}_4^{2-} \) in the soil. Coal fly ash samples from Savana river were studied for differences in physico-chemical properties by Menon et al. (1990). The fly ash samples differed considerably in pH, conductivity and elemental...
composition. The transition metal appeared to bind more tightly on smaller particles than on larger ones. Wong and Wong (1986) compared the properties of fly ash with two types of soils. The fly ash was extremely alkaline and had a very high level of electrical conductivity compared with the other two types of soils. Both types of soils had the highest amount of macro-nutrients including total organic carbon, total nitrogen and total phosphorus, whereas, the fly ash had the lowest amounts. In contrast, the fly ash possessed extremely high concentrations of all the trace metals tested except Zn, compared with the two soils. Mishra and Shukla (1986) also compared the fly ash with soil. They studied particle size distribution in which silt was greater in amount in the fly ash while bulk density was less than the soil. Electrical conductivity, pH and nutrients were in high amounts in fly ash compared to soil. Deshmukh (2000) when applied graded levels of fly ash, bulk density was decreased while water holding capacity of soil was increased. The available NPK, micro-nutrients like Cu, Fe, Zn, Mn and exchangeable Ca and Mg were increased with fly ash application. The effect was non-significant on pH, EC and lime content and significant effect on CEC. Kene et al. (1991a) added fly ash to soil at the rates 0, 5, 10 & 15% (W/W). Fly ash addition
significantly reduced water holding capacity, bulk density, contents of free lime, organic carbon, total and available N,P,K and CEC of the soil, and increased the contents of fine sand which improved texture of the soil. Similarly, Khan et al. (1997) observed that the porosity, water holding capacity, CEC and conductivity were higher in fly ash; sulphate, carbonate, bicarbonate and chloride contents, concentrations of P, K, Ca, Mg, Mn, Cu & Zn were also higher in fly ash than in field soil. But N was present in low amount in fly ash. Singer and Berkgaut (1995) worked on cation exchange properties of hydro thermally treated coal fly ash. Approximately 50% fly ash could be converted to Zeolites. The CEC reached at 2.5-3.0 mequiv/g. Concentrations of extractable B, Mo and Se in fly ash were decreased. Fleming et al. (1996) investigated the leachability of metal municipal waste incinerators under acidic conditions. Significant increase in extraction of Cd, Cr, Zn, Pb, Hg, and Ag ions from the ash was attributed to the instability of the mineral phases that contain these metals under acidic conditions.

Sims et al. (1995) studied adsorption and disadsorption of phosphorus in soil amended with various concentrations (0-30%) of fly ash. Fly ash increased soil phosphorus from 13-34 mg/kg (20-30% fly ash) which enhanced plant growth. Kukier
et al. (1994) tested two fly ashes from Georgia as a source of boron for corn growth on two soils of different textures. Both soils (cecil and lake land soil) showed a linear relationship between fly ash rates and hot water extractable soil boron which increased with decreasing pH.

**Effect of fly ash on plants**

Since fly ash has all the micro- and macro-nutrient elements, it is now used as non conventional fertilizer for the improvement of plant growth and yield. Plant growth and yield of tomato was found better when fly ash was applied to soil particularly at lower dosage (Khan and Khan, 1996). Matte and Kene (1995) evaluated the effect of different levels (0, 5, 10 and 15 tonnes/hactare) of fly ash on Kharif crops (cotton, sorghum, groundnut, soybean, green gram and mustard). Application of 10 tonnes fly ash/hectare gave the best results. When fly ash was added in the soil at the rates of 0,5,10 and 15% w/w, the beneficial effects on growth and yield of sunflower were observed upto 10% amendment of fly ash (Kene et al., 1991b). The groundnut was grown with fly ash (0,5,10,15t/h) and fertilizers (0:25:50:0, 18.75:37.50:0Kg N:P:k/h). Fly ash application decreased maximum water holding capacity and increased NPK and exchange Ca$^{2+}$, Mg$^{2+}$
and trace elements (Zn, Cu, Fe and Mn). The best rate for improving soil properties was ten tonnes of fly ash per hectare (Kuchanwar et al., 1997). Singh and Singh (1986a) studied the response of rice cv. Madhuri to different levels of fly ash application at varying fertility levels in saline soil. Fly ash at 20% level significantly increased the contents of N,P,K at all growth stages and uptake of these nutrients by grain and straw. Scotti et al. (1996) studied the effect of fly ash on chichory (Cichorium intybus) grown in two soils with or without (3% and 10%) fly ash. Addition of 3% fly ash showed significant increase in yield.

Pasha et al. (1990) observed that soil amendment with fly ash (10% and 20%) improved plant growth, yield and chlorophyll contents of leaves of cucumber plants. Tripathy and Sahu (1997) found that 50% fly ash applied to soil increased height, girth, leaf number, leaf area, spike length and dry weight of wheat plant. Soybean plants grown in fly ash amended soil showed significant increase in plant growth, yield, leaf pigment, protein and oil contents of seeds at 25 & 50% fly ash level (Singh, 1993, Singh et al., 1994). Sajwan et al. (1995) used sewage sludge and fly ash mixtures in ratios (4:1, 4:2, 4:3 & 4:4) and application rate to soil was- 0, 50, 100, 150, 200 and 400t/acre. Plant growth and yield improved
at 50-100t/acre. Sahu and Dwivedi (1999) showed that seed germination in *Vigna mungo* and *Abelmoschus esculentus* was highest at 25% concentration of fly ash, while the plant growth of both the plants was best at 50% concentration. The chlorophyll content was maximum at 50% concentration in *V. mungo*, whereas, it was maximum at 25% in *A. esculentus* plant.

Fly ash contains very small amount of nitrogen. Plant growth, yield, leaf pigments and seed proteins are affected adversely through poor nitrogen availability in fly ash amended soils (Wong and Wong, 1986, 1989). Singh (1993) reported that root nodulation and leaf nitrogen gradually decreased with an increase in the fly ash concentration from 60% level. Garau et al. (1991) reported that net nitrogen mineralization decreased as the rate of fly ash application increased. However, the effect of fly ash on nitrogen mineralization was also dependent on its composition. The application of 50t/ha fly ash did not significantly affect the nitrogen mineralization.

Bhaisare et al. (2000) conducted an experiment during summer 1993-94 on green gram (K-851) with three levels of N (0, 18.75, 25Kg/ha) and P(0,37.8, 50Kg/ha) and four levels of fly ash (0,5,10 & 15t/ha) on vertisol. Results showed that
significantly highest yield of grain and straw along with highest content and uptake of nutrients were recorded with the increasing levels of fly ash up to 10 t ha\(^{-1}\). Further increase in its application did not show any advantage. The highest content of crude protein and test weight were recorded by same level of fly ash. Amongst the fertilizers, green gram responded well to higher doses of N and P fertilizers for yield, quality and nutrient uptake. Combined effect of fly ash and fertilizers was non-significant.

Fly ash also contains some toxic substances along with heavy metals in appreciable amount that have bad impact on plants. Inhibition in root nodulation on legumes was reported in soil amended with fly ash at higher levels by Singh (1989). He suggested that heavy metals present in fly ash might have caused suppressed growth. The root length and cotyledons length of seedlings of desert annuals decreased with increased fly ash treatment up to 50% (Vollmer \textit{et al.}, 1982). Sajwan \textit{et al.} (1995) observed the reduced yield of plant at higher application rate of fly ash. This might be due to assimilation of high levels of boron, which was phytotoxic. The amount of N, P, K, Ca, Mg, Mn, Fe, B, Cu, and Zn in both soil and plants were in elevated concentrations. Sikka and Kansal (1995) found that yield of rice was increased significantly at 2-4%
w/w due to input of N, S and Fe from fly ash, while it was reduced at 8% fly ash level due to lower P and Zn availability and possible toxicities of other elements. McMurphy et al. (1996) noticed that fly ash causes alternation in the maize genome, when plants were grown in soil mixed with fly ash. It also reduced the soil genotoxic effects. Sahi and Singh (1996) showed that heavy metals present in fly ash caused genetic damage to *Allium cepa* which led to death. Gupta et al. (2000) found that fly ash exhibited reduced growth of nodulation, chlorophyll, carotenoid, protein contents and nitrate reductase activity, and the elements Fe, Zn, Cu and Mn accumulated in large quantities in plants.

**Brick-Kiln Dust**

Brick-kiln dust is a second major air pollutant among the particulates in India, emits from the brick-kilns during coal-combustion. Rapid growing population, great race for rapid urbanization and industrialization need more and more bricks for construction. In India, fire clay bricks are produced in about 40,000 small brick-kilns and clamps which operate seasonally using around 40-50 lac tonnes of coal each year (Mishra et al., 1987). The harmful gases and solid components which are released from kilns after combustion, adversely
affect the atmosphere, hydrosphere, lithosphere and whole biosphere. The consumption of coal is about 18 tonnes for preparing one lac bricks. The product of complete combustion of fuel in brick-kilns mainly consist fluoride, carbon dioxide, water molecules, oxides of nitrogen, sulphur dioxide, sulphur trioxide in gaseous form and brick-kiln dust in powdered waste form. Brick-kiln dust is a mixture of soil and ash of coal+wood which are left after consumption in kilns. The air pollution levels near these kilns have assumed significant importance, as they not only pose serious occupational health hazards, but also adversely affect the crops, fruit plantation and nearby buildings (Aslam et al., 1994).

Effect of brick-kiln dust on plants

Shyu et al. (1999) investigated the fluoride accumulation in leaves of banana and betel nut near a brickyard over a 14 months period. Periodic sampling was performed at 7 sites within a 4-km distance from the brickyard and at a non-pollutant area 20 km away. The mean leaf fluoride content in leaves of banana and betel nut at the 7 sites around the brickyard was 50.1 and 119.9mg/kg dry weight respectively. These figures were more than 4 times higher than those of the samples collected from the non-polluted area, 11.2mg/kg for
banana and 20.9mg/kg for betel nut. The data also indicated a distinct seasonal variation of leaf fluoride content. Samples collected between May and September was 0.3-0.6 and 0.4-0.7 fold respectively, of the yearly mean fluoride content. The soil fluoride content ranged from 0.69-4.13mg/kg. Jain et al. (2001) analysed that SO$_2$, NO$_x$, CO and HC are insignificant polluting parameters near brick-kilns. However, human health, flora and fauna and visibility are worst affected in the proximity of a brick-kiln. Sum and Su (1985) shown the acute symptoms of tip necrosis on leaves of rice plants grown in ceramic and brick industry areas of Taiwan. The severity of the injury increased by increasing fluoride concentration in rice leaves. There was an 80-fold difference in fluoride concentration between healthy and severely injured leaves. Fumigation of rice seedlings with HF induced symptoms on leaves similar to those occurring in nature. Results suggested that fluoride emitted from the ceramic and brick factories caused the rice disease. However, the effect of brick-kiln dust on plants is not available so far. There are various elements, which can be used to prepare low cost burnt bricks. According to Gowande et al. (1993) the average compressive strength of unburnt clay soil block in combination with cotton stalk (90:10) was 10.50kg/cm$^2$ while, compressive strength in burnt
blocks of soil with aluminium (96:4) was 26.63 kg/cm² and of soil with cotton (95:5) was 21.5 Kg/cm².

The particulate matter poses large surface areas and hence appear to form attractive sites for sorption of various organic and inorganic matters. Rai and Kumar (1999) investigated suitability of brick-kiln dust and fly ash for removing chromium (VI) from waste water. Both adsorbents exhibited fairly good sorption potential for chromium (VI) with a maximum at pH 1.3.

An estimate indicates that particulate contaminants contain more than 20 metallic elements. The most abundant are calcium, sodium, silicon, aluminium and iron, considerable quantities of zinc, lead, copper, magnesium and manganese (Martens and Beahm, 1978). Kulshreshtha et al. (1995) reported the nature and source of atmospheric aerosol near the Taj Mahal. They found that heavy metals Na, K, Ca, Mg, Fe, Al, Mn, Si, Ni, Cu, Zn, Pb and Cd were associated with the soil derived elements, industrial processes, wood combustion and brick-kilns. These heavy metals affect adversely on the plant growth and yield. Brown et al. (1986) studied the effects of increasing Zn concentration on germination, survival and growth of birch. Germination was decreased with elevated zinc levels. Distinct differences were found for percentage survival
and growth. Radical elongation was more adversely affected as compared to hypocotyl extension. Godbold and Huttermann (1985) found the inhibition in root elongation of *Picea abies* seedlings when assessed against the toxicity of Zn, Cd, and Hg. Xingfu (1989) planted the kidney beans in the soils where concentration of the metals in soil was higher. The growth of kidney beans was restricted in heavy metal polluted soils compared with controls. Metal concentration and metal uptake by plants were correlated. The highest relationship was found between amount of metal uptake and the metal concentration in exchangeable carbonate forms. Hetal *et al.* (1999) investigated the uptake of Cd and Zn by *Leucaena leucocephala*, a leguminous tree cropped for fodder and green manure. This was affected by the addition of 10mM NaCl to irrigation water. Salinized plants showed shorter roots, reduced retention of Cd and Zn in roots and stems and considerable translocation of both elements to the leaves. They suggested that NaCl salinity affects not only the bioavailability of Cd and Zn in soil but also modifies plant functions related to their acquisition and translocation to the leaves. The results provided the evidence that the risk of transfer of heavy metals to the food chain and their
leachability to the ground water may be greater under saline conditions than generally assumed.

**Oilseed Crops**

India is one of the leading oilseed producing countries in the world with 21% of the world's area and 15% of the world production. Oilseeds come in second largest agricultural commodity after cereals sharing 13% of the country's gross cropped area and accounting for nearly 5% of gross national production and 10% of the value of all agricultural products. There are 9 main annual oilseed crops: groundnut (*Arachis hypogia* L.), rapeseed (*Brassica campestris* L.), mustard (*Brassica juncea* L.), sesame (*Sesamum indicum* L.), sunflower (*Helianthus annus* L.), safflower (*Carthamus tinctorius* L.), soybean (*Glycine max* L.), niger (*Guizotia abyssiniea* (L.) cross), castor (*Ricinus communis* L.) and linseed (*Linum usitatissimum* L.) (Reddy and Pati, 1998). Oilseeds are rich sources of oils and valuable proteins. Oilseeds and oilseed meals have an important role in relieving the malnutrition and calorie nutrition of the human and animal population. In addition, the vegetable oils are useful as lubricants, surface coatings and as raw material for various industrial products.
Brassica juncea L. (Mustard)

*B. juncea* (Indian mustard or brown sarson) belonging to the family Brassicaceae, commonly known as rai, is an oil yielding rabi crop of India. The average yield of oleiferous (*Brassicas*) in India is 748Kg/ha (Anonymous, 1988). India occupies the second position in the world with regard to the production of *Brassicas*. However, it is considerably poor as compared to the world's 1207kg/ha yield (Anonymous, 1985). *B. juncea* accounts for approximately 80% of the total production of *Brassicas* in India (Anand, 1989).

Solanki and Chauhan (1993) studied the different levels of salinity on seven cultivars of *B. juncea* namely CS-12, CS-50, CS-416, CS-52/AS, Varuna and Pusa bold. The different levels of salinity caused marked reductions in total yield, 1000 seed weight and oil content. Singh *et al.* (1993) studied the effect of various doses of gamma rays and different concentrations of ES, *Streptomycin acriflavin* and ethidium bromide on *B. juncea* var. Pusa bold. They found that all the treatment reduced the time taken for germination, germination percentage, seedling growth and total biomass except ethidium bromide, which enhanced the size of cotyledonary leaves.
A field experiment on mustard was conducted to study the effect of irrigation and sulphur on the concentration, uptake and availability of sulphur, nitrogen and phosphorus. These contents in soil were significantly increased with every successive increase in level of sulphur. After harvest, the highest sulphur, nitrogen and phosphorus contents in soil were observed in treatment 60Kg S ha-1, which was significantly superior over rest of the treatments. The lowest contents were observed in control (Raut et al., 2000). Tomar (1996) studied the effect of nitrogen and sulphur on physiological components of *B. juncea* in clay loam soil. Physiological parameters viz. leaf area index, absolute growth rate, crop growth rate and net assimilation rate, relative growth rate and leaf area ratio were enhanced significantly except NAR with increasing levels of nitrogen upto 90Kg/ha and sulphur 45Kg/ha at every stage of growth. The NAR was decreased with increasing levels of N and S. Tripathy and Sahu (1998) observed the effect of fly ash levels on mustard. Growth and yield increased upto 50% fly ash level.

*Linum usitatissimum* L. (Linseed)

*L. usitatissimum* (Linseed), belonging to the family Linacea, is an important oilseed and fibre yielding crop. One
of the first oilseed crops to be cultivated systematically was probably linseed. There is fossil evidence of the selection for agriculture of soil-bearing varieties of linseed from over 8000 years ago. Their first mention in written records is found in ancient Sumerian and Akkadian texts dating from 4000 to 5000 years ago, which refer to oilseeds such as sesame and linseed. Linseed is a double purpose crop grown for either oil extraction from seed or fibre from the stem.

Mohammad (1994) advocated that, depending on soil nitrogen status, judicious combination of soil and leaf applied nitrogen could be exploited to increase the productivity of linseed. Sanchez and Flores (1999) observed effect of N in different doses on linseed cv. Tapa INTA. The doses were 0, 40, 80, 120 or 160 Kg of N/ha. Nitrogen increased seed yield and seed dry matter as a proportion of total dry matter, with no significant differences among N rates. Sarode et al. (1998) studied yield and nutrient harvest pattern of linseed. These were influenced by graded level of nitrogen and phosphorus i.e. 0-60 Kg N and 0-60 Kg P₂O₅ /ha. Seed and straw yields increased with upto 60kg N and 30 kg P₂O₅. Uptake of N, P and K followed a similar pattern, while uptake of Ca and Mn increased upto the highest P rate. Uptake of Zn and Fe was increased by N application but decreased by the highest P rate.