# REVIEW

# OF

# LITERATURE

# CHAPTER – 2
# REVIEW OF LITERATURE

Future is the manifestation of the past. So past research studies would have the way for the future researchers. It also provides a basis to theoretical framework in addition to helping researcher to get an insight in to methods and procedures. Thus a is the manifestation of the past. So past research studies would comprehensive review of the literature is an eventual part of any investigation.

## 2.1. AMBIENT AIR QUALITY MONITORING

Many of the metropolitan cities in India are ranked amongst the top few cities of the world for air pollutants concentrations. The analysis of National Environmental Engineering Research Institute (NEERI), India air quality data in 1990 for annual average of $SO_2$ concentrations reveals a trend for increasing concentrations (from 3.8 to 15.2 ppb) in most of the parts of northern region, except for a few cities including Delhi, that had mean annual $SO_2$ concentration above 22.8 ppb after 1985 (Agarwal *et. al.,* 1999).In 2009, scenario has changed as $SO_2$ concentration has declined throughout the country with concentrations varying between 1.5- 13.7 ppb.

Among metropolitan cities $SO_2$ concentrations in Delhi, Mumbai, Chennai and Kolkata were 2.3, 2.3, 3.4 and 6.1 ppb, respectively (ENVIS, 2010). Studies conducted in Varanasi city during 1999-2001 showed that $SO_2$ concentration ranged from 5.32 – 5.5 ppb (Trivedi *et. al.,* 2003). National ambient air quality standard given by Central Pollution Control Board (CPCB) in India (Baldasano *et. al.,* 2003).

They observed a large of almost 500 sq. km. region in South West of India, the industrial zone is intersected with two highways. The region experienced significant cumulative pollution load (CPL) of SPM, $SO_2$ & NOx i.e. 532µg/m3 during 1986-1990 and 251.66µg/m3 during 1999-2002. The CPL in area decreased during 1999-2002, maximum at Nayagaon-Khor i.e. 75% and minimum at Nagda i.e. 11% .In 1986-1990 except Pithampur where 37% increase in CPL new ambient air environment quality of Pithampur industrial area demonstrated a rising trend especially in gaseous pollutants i.e. $SO_2$ & NOx, 17.40 & 15.19 $\mu g/m^3$ (during 1986-

1990) to 23.66 & 34.49 $\mu g/m^3$ (during 1999-2002). The ground level ozone was never estimated for the region which ranged to 13- 34 $\mu g/m^3$ with area average of 17.58$\mu g/m^3$.Sulphur di oxide ($SO_2$) concentration in the ambient air of different sites in various industrial areas attained a maximum level of 65-71 $\mu g/m^3$. The result shows that there is a decreasing trend of $SO_2$ at all study sites during 1999-2002. The maximum decrease is at Nimbaheda & Nagda i.e. 52 & 51% respectively with reference to 1986-1990 loads.

This may be due to modification of coal quality and technology inputs. Oxides of nitrogen (NOx) concentration in the ambient air at selected sites attained the maximum levels of 58 & 68 $\mu g/m^3$ at Dewas and Nagda respectively during the year 1986-1990, after ten years the NOx concentration is decreased at Dewas and Nagda by 7 & 23% respectively while at other three areas NOx concentration increased. The maximum increase in NOx concentration is at Pithampur 87%, at Nimbaheda 49% and at Nayagaon-Khor 27%. In all of these places highways cross the industrial zones. At Pithampur it may be due to high industrial activities and increased traffic density (Krishna Haryani, Prem S. Dubey and Kailash C. Sharma., 1999-2002).

The study deals with the ambient air quality of Tantra-Raikela-Bandhal iron ore mines with respect to suspended particulate matter, sulphur dioxide ($SO_2$) and oxides of nitrogen (NOx) and their level of concentration in different seasons of the year ( Das SK, *et. al.*, 2003).The justification of selecting air-monitoring stations and focuses on the methodology adopted for sampling and analysis to evaluate status of air pollution mines and four seasons monitoring data revealed that SPM, RSPM, $SO_2$ and NOx concentrations at different locations industrial, residential and sensitive exceeded the Permissible limit. The study reveals that high coal production associated with heavy. Mechanization led to more air pollution problem in areas (Ghose Mrinal K, *et. al.,* 2003).

In this studies showed that the spatial patterns of various criteria air pollutants at Shahdara National Ambient Air Quality Monitoring station in Delhi (India) and these spatial patterns were found to be essentially the same before and during rain, however a significant decrease in $SO_2$, $NO_2$ and TSP concentrations (40-45%) was observed after initial and subsequent rains of the monsoon, demonstrating the importance of rainfall in the scavenging of these criteria air pollutants ( Ravindra Khaiwal, *et. al.*, 2003).

Air Quality Index (AQI), in major metropolitan cities, where different types of activities, viz. industrial, commercial and residential were in progress. To make the index more informative, air quality index was classified in to five different categories viz.Clean, moderate, poor, bad and dangerous. Long term AQI was then calculated for metropolitan cities. AQI of Mumbai, Delhi, Calcutta, Chennai and Nagpur like fast dveloping cities , was calculated according to National Standards (Siddiqui *et. al.*, 2007). The high surface $O_3$ levels (120 ppb) in Jakarta during January 2002-March 2004, which frequently exceeded the hourly national ambient air quality standard ( Permadi and Oanh., 2008).

In 2009 that scenario has changed as $SO_2$ concentration has declined throughout the country with concentrations varying between 1.5- 13.7 ppb. Among metropolitan cities $SO_2$ concentrations in Delhi, Mumbai, Chennai and Kolkata were 2.3, 2.3, 3.4 and 6.1 ppb, respectively (ENVIS, 2010). Studies conducted in Varanasi city during 1999-2001 showed that $SO_2$ concentration ranged from 5.32 – 5.5 ppb. Annual mean concentration of $NO_2$ ranged from 10.1 to 31.3 ppb in different zones of Varanasi city, situated in eastern Gangetic plain of U.P in 1990, whereas the same varied from 16 - 155 ppb during 1999-2001 (Trivedi *et. al.*, 2003).

The assessment of ambient air quality with respect to suspended particulate matter (SPM), sulphur dioxide ($SO_2$) and oxide of nitrogen (NOx) at four sites in the Raniganj-Asansol area in West Bengal, India. It has been observed that the concentrations of the pollutants are high in winter in comparison to the summer or the monsoon seasons. Results indicates that industrial activities, indiscriminate open air burning of coal by the local inhabitants for cooking as well as cooking purposes, vehicular traffic, etc. are responsible for the high concentration of pollutants in this area (Reddy G.S., *et. al.*, 2003).

The SIPCOT (State Industries Promotion Corporation of Tamil Nadu Limited) industries are playing an important role in the economic development of India. The effluents released by them produce a high degree of pollution in the air, soil and aquatic systems and SIPCOT has set up of a 200 hectare estate, 8 km away from

Cuddalore town, South India and it consists of big and small units manufacturing pesticides, pharmaceuticals, chemicals, plastics, dyes and textiles (Ramamurthy N., Kannan S., 2009).

Total $SO_2$ emission shows a decreasing trend since 1980 (USEPA.,2007). $SO_2$ emission decreased by 53% from 1990-2006. United States Environmental Protection Agency reported that annual $SO_2$ emission was 31.2 and 15.8 million tons in 1970 and 2003, respectively (USEPA, 2007). According to the RAINS estimates, the world emissions of $SO_2$ in 1990 were about 120 million tons, while in 2000; the emissions were about 20% lower than 1990 level. Current energy and air pollution control policies cause a further 5% decrease till 2010- 2020 (Cofala *et. al.,* 2007).

The Studies conducted during 1999 to 2000 in Varanasi city showed that 6 hours (10 AM to 4 PM) $O_3$ concentrations varied from 9.2 - 48 ppb in summer and 7–45 ppb in winters in periurban areas (Agrawal *et. al.,* 2006). Another study conducted by Agrawal *et. al.,* (2003) showed $O_3$ concentrations (6 h) ranging from 10.3 to 15.4 ppb during and from 9.7 to 58.50 ppb during summers at different sites in Varanasi city. Study conducted at suburban areas of Varanasi during 2002- 2006 reported that $O_3$ concentrations (12 h) ranged from 45.18- 62.35 in summer, 28.55- 44.25 ppb in winter and 24.09- 43.85 ppb in rainy season (Tiwari *et. al.,* 2008).

NOx emissions in Asia increased about 2.5 times from 1980 to 2000. Monitoring of air quality in Indian cities conducted by Central Pollution Control Board (CPCB, 2009) has shown a trend of dramatic increase in NOx concentrations since 1990 especially in the metropolitan cities. According to the monitoring, conducted by Garg *et. al*., (2001), NOx emissions over the Indian region are growing at an annual rate of 5.5% year-1. Annual average NOx concentrations varied from 4.3 to 42.9 ppb in various parts of the country (CPCB, 2009). In the present scenario, $NO_2$ concentration is critical in Howrah (eastern region) where annual mean concentration is 42.9 ppb while it was 31.8 ppb in 1990. In other parts of the country, however, $NO_2$ concentrations were reported within the prescribed standards (CPCB, 2009). Annual mean concentration of $NO_2$ ranged from 10.1 to 31.3 ppb in different zones of Varanasi city, situated in eastern Gangetic plain of U.P in 1990, whereas the same varied from 16 - 155 ppb during 1999-2001 (Trivedi *et al.,* 2003).

Air Quality Monitoring and carried out four main pollutants viz.SPM, RSPM, $SO_2$, and NOx for four years. They found towards higher side. The study also found out the presence of other pollutants like aerosols, heavy metals, and poisonous gases etc. and suggested that these pollutants should also be monitored from time to time which will help in combating air pollution problem of the city (Sengupta *et. al.,* 2002-2006). Stone dust is a primary aerosol and it is released directly from the source. It has a detrimental effect on people and environment including flora and fauna, for example, changed soil pH and productivity, formation of haze reducing visibility in the surrounding areas, destruction of habitat, damage of natural resources like valuable vegetations and wildlives, promotion of spreading of many diseases etc.(Semban and Chandrasekhar, 2000; Das and Nandi, 2002; Mishra, 2004; Sivacoumar *et. al.,* 2006). Effects of cement, petroleum–coke dust, fly ash, coal dust, automobile exhaust and other airborne particulates on various morphological and physiological parameters in different plants (Verma and Singh, 2006; Prajapati and Tripathi, 2008).The suspended particulate matter (SPM), depending on the size and weight of particles; remain in the air for varying length of time. Those larger than 10 μm in size settle under forces of gravity on surfaces of vegetations and soil but the smaller ones remain suspended in air for longer periods of time, get dispersed and diffused by the wind, and eventually deposited on various surfaces including foliar ones (Rao, 1985*).*

Higher level of $SO_2$ in the atmosphere leads to direct damage to coniferous trees including non-specific chloroses, necroses, growth inhibition and impairment of reproduction. Both $SO_2$ and $NO_2$ react with dissolved oxygen in water vapour to form acid mist. Precipitation transports these acids into the soil and triggers indirect damage to crops. $NO_2$ in air under solar radiation decomposes to form NO and O radicals which then react with hydrocarbons and oxygen to form a number of compounds such as aldehydes, organic hydroperoxides, peroxyactyle nitrate and ozone. Production of ozone near ground level results in the formation of photochemical smog and its concentration above 0.25 ppm causes eye irritation and impaired lung function (Scheeidegger C., and Schroeter B., 1995).

In pollution studies, Air Particulate Matter (APM) plays an important role not only for the reason that it by itself is hazardous but also provide a platform for chemical reactions to produce secondary pollutants and eventually becomes the carrier of toxic pollutants as well. According to a recent survey by Asian Development Bank (ADB) and World Bank in some of the world's largest cities, the levels of suspended particulate matter (SPM) are now routinely exceeding WHO guidelines (WHO/UNDP, 1992). IAEA study in which institutions from 40 countries were involved including our Lab. revealed that among 12 of the worst affected cities, where more than a factor of 2-10 has recently exceeded WHO guidelines, are in Asia (i.e. Bangkok, Beijing, Mumbai, Calcutta, Delhi, Jakarta, Karachi, Manila, Seoul, and Shanghai (Parr, R.M. and Smodis B., 1999).

The aerosol also dominates the optical effects in the atmosphere: The visibility in clean air is estimated to be 340 km which reduces to 43 km by presence of 20 ug $m^3$ of particles of average continental aerosol. Beside their crucial role in atmospheric chemistry, aerosol may also cause cooling. Fine particles of size 0.4 to 0.8 ug impair visibility by absorption and scattering of light. This absorption and reflection of light by these particles may also cause cooling which is known as White-House effect. The recent highly controversial estimates of both direct and indirect radiative influences of greenhouse effect on earth's climate (so called forcing of climate) amount to+3.0=0.9 $W/m^2$ (Watt/Meter),and those of the White- House effect is -3.0=2.0 $W/m^2$ . Obviously there is still a large uncertainty associated with the aerosol-forcing estimate, which reflects the unsatisfactory data regarding the sources, distributions, properties, and time variations of atmospheric aerosol (Kucera, J. & Charlson, H. and Heintzenberg, J., 1994).

In cement industries, dusts are released in to the atmosphere, with both viable and latent consequences on ecosystem components and have been common air pollutant in the vicinity of the manufacturing plant. The significant rate of particulate emission and toxic metals associated with particulates have prompted the work of estimating some crustal (Soil origin, namely Fe, Mn, etc.) as well s anthropogenic (industrial Origin) elements which are hazardous in nature of public health point of view. Particle size range of cement dust is between 0.1to 100µm.It contains varying quantities of oxides of Ca, K, Na with lesser amount of Si, Mn, Mg, Ni,Cu, Zn, Pb, Cd, Co.etc (Reddy B.M. Dubey S., & Dubey P. S., 2002).

The most common combination of coarse particles consists of oxides of silicon, aluminum, calcium, and iron (USEPA, 1982b). Particulate matter (PM) has been widely studied in recent years and the United Nations estimated that over 600 million people in urban areas worldwide were exposed to dangerous levels of traffic generated air pollutants (Cacciola *et. al.,* 2002).The deposition of gaseous pollutants and particulate matter and their interception are greater in woodlands than in shorter vegetation (Fowler *et. al.,* 1989; Bunzl *et. al*., 1989)

Guru Gobind Singh Thermal Plant, Ropar (Punjab) is using about 13000 MT of coal per lay. Such a huge coal burning per day has visible effects on human beings and plants. These factors lead to the investigations of suspended particulate matter (SPM) and $SO_2$ emissions going out and its effects on vegetation. Although electrostatic precipitators (ESPs) have been installed to control SPM but these are not adequate and the results are much above the defined limits. Moreover ESPs are not the devices for controlling $SO_2$ emissions. The physical survey of green belt (Singh Charanjit *et. al.,* 1994).

Air quality monitoring of Varanasi city indicates a logarithmic normal distribution pattern of 2-h mean concentrations of $SO_2$, $NO_2$, and $O_3$. Ozone concentrations peaked from late morning to afternoon of summer and those of $SO_2$ and $NO_2$ during early morning and late evening of winter months. The coincidence in the timing of $SO_2$ and $NO_2$ peaks appears interesting from the biological perspectives (Pandey J., *et. al.,* 1994*).*

The general features of AQI were descried. A case study of regional area is illustrated through computation technique of an AQI with respect to the exceedance factor (EF).The study reveals the SPM level in areas of Indore city have reached the critical level since last seven years (Gupta *et. al*., 2008).

## 2.2. ASSESSMENT OF CROP RESPONSE

Review of the symptoms of acute $SO_2$ injury in vegetation will be summarized in the succeeding paragraphs. Concentration of $SO_2$ known to cause injury in a variety of plants .Dose- response concentration will depend on exposure time. Short, high doses are probably more repetitive of industrial emissions and /or accidents. It is important to note that many of these concentrations will be based on experimental condition and more field evidence is requiring (Taylor *et. al.*, 1990).

The symptoms of acute damage ($SO_2$>1ppm) are necrosis on the upper and lower leaf surfaces, at the apices, margins and between the veins. The tissues around the stomata may also decompose (Kovacs, 1992). Water soaked appearances on leaves in many species. Specific colored leaf is common. For example light brown necrosis in daffodil, grey necrosis in geranium and black necrosis in broad beans. Tips necrosis on seals has been observed in marigold and gladiolus. Necrosis on awns of grasses and cereals has been reported. Barley, bracken and clover regards very sensitive species to $SO_2$ exposure. Many species show water soaked appearances on the leaves followed by necrosis in response to acute NOx exposure.

Leaf glazing has been observed in annual Poa, cabbage and spinach .Necrotic streaking and internal necrosis has been recorded in many narrow-leaved and broad-leaved species. Legumes among many other species show ivory necrosis while some species display yellow, Orange or brown necrosis. Tip necrosis has been observed on other plant parts awns, bracts and sepals (Taylor *et. al.*, 1990).

Air pollutants can produce a wide range of visible symptoms (acute injury) on crops & Injury to plants as a result of pollutants has been classified as either chronic or acute. An acute injury is viewed as a short duration high level of $SO_2$. On broad-leaved plants, acute $SO_2$ injury symptoms consist of bifacial, marginal and/or interveinal necrosis and chlorosis on leaves at the full stage of development. The necrotic areas can range in colour from white to reddish brown to black depending on the plant species. In monocotyledonous plants, acute injury symptoms start at the tip of the leaves and spread downward as necrotic and chlorosis streaks with occasional reddish pigmentation. Chronic $SO_2$ exposure may or may not result in foliar injury symptoms depending upon plant susceptibility. It is important to note that reductions in plant growth and Productivity from chronic exposure may occur without development of visible chronic foliar injury (Legge and Krupa, 2002)

Effect of ambient air pollutants on wheat and mustard crops growing in the vicinity of urban and industrial areas showed that changes in morphological characteristics, photosynthetic pigment and yield of those plants. The study clearly show that gaseous (NOx and $SO_2$) and particulate pollutants such as SPM and RSPM have detrimental effects on wheat and mustard crops. Changes in morphological characteristics, photosynthetic pigment and yield of wheat and mustard plants directly corresponded to the levels of air pollution at different sites. The study elucidates that air pollution emitted from urban and industries adversely affecting the ambient air and agricultural production. It is very clear that urban and industrial air pollution has become a serious threat to agricultural production grown adjacent to urban and industrial areas. More research is, however, necessary to evaluate the contribution of individual and in combination of air pollutant on crop production and its losses (Chauhan Avnish & Joshi P.C., 2010).

The collated information based on field experiments concludes that air pollutants not only affect the vegetation near the point sources and urban centers, but depending on the meteorology, specially wind pattern may spread in suburban and rural areas, affecting the crops. Air pollutants cause deleterious effects on physiology and metabolism of plants due to their oxidizing potential. Responses of plants vary between different species and their cultivars. Responses of plants to air pollutants also depend on type of pollutants, concentrations duration and its magnitude. There is a need to screen out sensitive and tolerant cultivars in India and establish the exposure indices of all the important crops to reduce the crop loss (Richa Rai, Madhu Rajput, Madhoolika Agrawal and S.B. Agrawal 2011).

In case of $SO_2$ and $NO_2$, visible injury usually results from exposure to pollutant concentrations above a point around an order of magnitude greater than the threshold for growth and yield reductions in absence of visible, i.e.chronic injury, however, in case of $O_3$, acute visible symptoms can be produced on sensitive species within a range of approximately twice the maximum natural concentration of this pollutant. Thus, visible $SO_2$ and $NO_2$ injury is largely confined in the field to severely polluted locations or on the occasion of large industrial accidental releases. In contrast, visible $O_3$ injury is recorded more frequently over worldwide areas when an elevated level of this pollutant occurs. Acute injury by these pollutants vary in their form of various necrotic lesions, ranging from a fine stipple to large patches of dead tissue, with colouration ranging from white to brown black (Taylor *et. al.*, 1987).

Low concentration of $SO_2$ stimulated stomatal conductance in *Vicia faba* L. within 15 mins of exposure, which persisted for several days. This has been attributed to the destruction of epidermal cells adjacent to stomata and accumulation of sulphur within guard cells. Larger stomatal apertures not only allow ingress of the damaging pollutant, but also enhance water loss due to unrestricted transpiration (Black and Unsworth., 1980).

Due to urbanization and industrialization, there is an immense loss to the yield and in turn to the economy of the region. Hence APTI determination to various crops provides information regarding the tolerance capacity of them to air pollutants and such crops may be recommended to the farmers in industrialized urban and peri-urban areas. In present study higher APTI in industrial site sample is revealed that the pulse yielding crop *C. cajan* is one of the suggestible crops to increase the revenues of farmers and the region (Meerabai. G., *et. al*., 2012).The impact of industrial air pollutants on some biochemical parameters and yield in wheat and mustard plants (Joshi N., A. Chauhan *et.al.*, 2009).

Our present study correlated with previous investigation of Dubey, (1990 & 1997) studied that a comprehensive long-term research of about 18 years of air quality in the selected sites upto 5-7 km area with wide microclimatic conditions and various types of crops. The sites were around Dewas, Nagda, Pithampur, Nayagaon-Khor and Nimbaheda (Raj.) industrial areas. Air pollutants in combination may induce antagonistic or synergistic impacts on plants depending upon the specific pollutants and their concentrations, exposure duration and environmental condition. Assessment of crops and fruits loss due to air pollution in SW M.P. was done and a final technical report of ICAR sponsored project, ministry of Agriculture and forestry, Govt. of India, New Delhi, investigated the deterioration of ambient air quality over all the years at these sites and practically in the overall regional sectors around industries and highways. It is apparent that ambient air quality has improved in some regions especially with reference to cement production but it has deteriorated in fastly developing industrial zones. Shown the cumulative load induced latent crop loss (Dubey P.S., 2002).

Physiological and biochemical responses of two cultivars of wheat to elevated levels of $CO_2$ and $SO_2$, singly and in combination have shown significant reductions in physiological characteristics, pigments and above ground biomass of *Beta vulgaris*, *Triticum aestivum*, *Brassica compestris* and *Vigna radiata* at sites experiencing higher ambient concentrations of $SO_2$, $NO_2$ and $O_3$ as compared to sites with very low levels of pollutants. Studies with soybean showed significant decrease in chlorophyll content and photosynthesis rate at 60 ppb $SO_2$ (Agrawal *et. al.*, 2003).

Demonstrated grain yield reductions of 46 and 38% for two cultivars of winter wheat through open top chamber studies conducted in the vicinity of Lahore, Pakistan using ambient and charcoal filtered air (Wahid *et. al.*, 1995). Reductions of 43, 39 and 18% in yield of three wheat cultivars Pasban 90, Punjab 96, Inquilab 91, respectively at seasonal mean concentrations of 70, 28 and 15 ppb $O_3$, $NO_2$ and $SO_2$, respectively at Lahore, Pakistan (Wahid, 2006).20.7% reduction in yield of wheat cultivar M 234 grown at ambient air pollution level ($SO_2$ 7.8 ppb, $NO_2$ 40.6 ppb, O3 42.1 ppb) and at rural site in Varanasi, experiencing low concentrations of $SO_2$ 7.3 ppb and $NO_2$ 14.5 ppb and high $O_3$ concentration (35 ppb) found 10 and 14% reduction in yield of rice cultivars NDR 97 and Saurabh 950 grown at ambient ( Rai *et. al.*, 2007).

Li *et. al.*, (2007) several studies have shown that the disturbances caused by $SO_2$ to biochemical functions and cell structure (Jutawong and Suwanwarer, 1997; Tripathi and Gautam, 2007) of plants appear before visual symptoms or growth reductions. Li *et. al*., (2007)observed the physiological processes such as photosynthesis, respiration, stomatal activity; transpiration and translocation are reported to be adversely affected by $SO_2$.The entry of $NO_2$ into leaves is similar to that of $SO_2$, however, entry through cuticle is higher as cuticular resistance against $NO_2$ entry is lower than for $SO_2$ or $O_3$. A single exposure of *Euonymus japonica* to 100 ppb $NO_2$ led to an increase in stomatal conductance (Natori and Totsuka., 1984).

According to several studies photosynthesis (Ps), a core function in the physiology of plants is most susceptible to $O_3$. Reductions in this activity have been widely reported under ambient field conditions at higher concentrations of $O_3$ (Rai *et al*., 2007; Tiwari *et al*.,2006, Agrawal *et al*., 2003). Meta analytical analyses on several varieties of wheat (Feng *et al.*, 2008), soybean (Morgan *et. al.*, 2003, 2006) and rice (Ainsworth, 2008) also found varying degrees of response of photosynthesis to $O_3$.

Adverse effects of air pollution on biota and ecosystems have been demonstrated worldwide. Much experimental work has been conducted on the analysis of air pollutant effects on crops and vegetation at various levels ranging from biochemical to ecosystem levels. It has been observed that ozone concentrations are higher in suburban and rural areas as compared to the urban areas, whereas $SO_2$ and $NO_2$ concentrations are higher at urban site (Tiwari *et. al*., 2006). leaves are most susceptible parts of a plant to acute injury due to their abundance of stomata, which permit penetration of the pollutants into the sensitive tissues. The first barrier of gaseous air pollutant is boundary layer resistance which varies with wind speed and size, shape and orientation of leaves Heath *et. al*., (2009). Crop plants have the ability to take up atmospheric gases without active metabolism and therefore, vegetation serve as a natural sink for air pollutants by providing expanded leaves for the absorption and setting of gases and particulate matter. The $SO_2$ and $NO_2$ gases reduced growth and yield of crops (Gupta G, Sabratnam S., 1980).

Air quality on mung bean grown at different sites in peri urban fringes of Varanasi city. It should be borne in mind that this study was undertaken over the summer growing season when slower of metabolism, as a result of the extremely hostile environmental conditions, may have predisposed plants to susceptibility to pollutants. The experimental design did not permit clear elucidation of the relative contribution by the individual gases, although it is clear that $O_3$ forms an important component of the air shed in the more rural sites with no specific source of the primary pollutants $NO_2$ and $SO_2$. The present study clearly demonstrated that air pollution could be a major constraint on peri-urban crop yield and its nutritional quality in India. Research to establish exposure response relationships for a range of important crops, using long term chamber filtration experiments under local field conditions, is urgently required.

These studies could lead to recommendations for changes in agricultural practices to ameliorate the impacts of air pollution. Concern over air pollution today is largely based on direct impacts to human health. However, in view of need to maintain yields and address malnutrition in the developing world, there is a strong case for raising the policy profile of the indirect health impacts of air pollution through reduced crop yield and nutritional quality. These factors should be considered when assessing the true benefit of pollution abatement strategies (Agarwal M.A. *et. al.*, 2006).

Seed quality also showed significant variations between sites with respect to Starch ($F$ = 202.67; $P$ < 0.001), total sugar ($F$ = 115.40; $P$ < 0.001), reducing sugar ($F$ = 12.47; $P$ < 0.001) and protein ($F$ = 22.03; $P$ < 0.001) contents. There was no significant relationship between atmospheric $NO_2$ or $SO_2$ and foliar protein in the present study, although there was an indication of an $O_3$ effect. Starch content of seeds showed a significant negative correlation with both ambient $SO_2$ and $NO_2$ concentration .Reducing sugar showed no relationship with pollutant concentrations but total sugar was significantly negatively correlated with both $SO_2$ and $NO_2$. Possibly, reduced photosynthetic efficiency of plants at the more polluted sites has reduced accumulation and allocation of photosynthates to their seeds (Agarwal M., et *al.*, 2006).

In India, high levels of $SO_2$ can result in localized impacts on crops as demonstrated in the vicinity of industrial complexes. For example, Singh *et. al.* (1990) have shown yield reductions in several field grown crop species downwind of industrial sources of $SO_2$ in the Obra- Renukoot- Singrauli area of the Sonbhadra district in India.

Physiological and biochemical responses of two cultivars of wheat to elevated levels of $CO_2$ and $SO_2$, singly and in combination. have shown significant reductions in physiological characteristics, pigments and above ground biomass of *Beta vulgaris*, *Triticum aestivum*, *Brassica compestris* and *Vigna radiata* at sites experiencing higher ambient concentrations of $SO_2$, $NO_2$ and $O_3$ as compared to sites with very low levels of pollutant (Agrawal *et al.*, 2003). Maggs *et. al.* (1995) shown significant reductions in various yield parameters of both wheat and rice near Lahore at annual mean nitrogen dioxide ($NO_2$) concentrations of 20–25 ppb and 6 h mean $O_3$ concentrations reaching 60 ppb in certain months. In both cases the effect was attributed primarily to $O_3$.

Growth indices further reflect the mechanism of biomass allocation under different levels of air pollutants. Root/shoot ratio (RSR) did not show significant variations due to sites. Leaf weight ratio (LWR) ($F$ = 5.32; $P$ < 0.001), vegetative reproductive ratio ($F$ = 12.23; $P$ < 0.001) and harvest index ($F$ = 9.23; $P$ < 0.001), however, varied significantly among sites with differing concentrations of air pollutants. Higher LWR suggests partitioning of a large amount of fixed carbon into leaf growth to enable the plants to overcome the adverse impact at the place of impingement (Agarwal, M., *et.al.*,2006). Reduction in total biomass due to air pollutants is often accompanied by a change in partitioning of photosynthate in different plant components. No significant change in RSR of plants suggests that pollutants do not alter the partitioning pattern between below and above ground parts. This, however, is contradictory to some reports in the literature (Cooley and Manning, 1987; Kasana and Mansfield, 1986).

The nutritional contribution of legumes to the diet could be raised by increasing yields and by improving the quality and quantity of seed protein and their food use qualities (Khan 1991a). Dry soybean contain 36% protein, 19% oil, 35% carbohydrate (17% of which dietary fiber), 5% minerals and several other components including vitamins( Liu, K.S., 1997). Soybean species are widely used as components of food in all areas of the world. The species are adaptable to varying conditions of soil and climate, proliferate profusely and are generally considered as shrubs. With growing industrialization, the macromolecular composition of plants has been subjected to changes due to chemical pollutants. The effect of chemicals and agrochemicals on plant macromolecules has attracted worldwide attention of researchers (Okumura, M., A. B. *et. al.*, 1999).

The significance and mechanisms of such changes are still poorly defined. The few studies carried out so far indicate formation of free radicals which interact with proteins and lipids in some researchers have studied the change in plant composition to assess the level of pollution. A study of the effect of chemical pollutants on the molecular profile of plants from soybean seeds is of great significance due to the fact that the results may be indicative for other flora forms as well. Such studies have not yet been undertaken, so the results presented in the paper acquire added significance (Williams A. J.*et. al*., 1995).

Ozone also causes damage to trees and crops and induces premature ripening of fruits, which results into low yield. It reacts with photosynthetically active cells on the upper surface of leaves causing interveinal injury, which resembles dot like lesions called stipples. Peroxyacetyle nitrate is toxic and causes various health disorders. Fluorine is released from various industrial processes, mostly burning of waste and combustion of fossil fuels. Converted hydrogen fluoride with moisture damages the plants, primarily causing necroses on leaf edges (marginal) and tips (terminal). Accumulated fluoride in plants, damages leaves and inhibits growth. High concentration exposure of humans leads to bone deformation and brittleness (Ahmad S., *et al.,* 2007). In the United Kingdom simulating Chinese agriculture and an $O_3$ concentration regime similar to Chongquing (15–75 ppb, 7 h daily mean > 59 ppb, over 28 day period) showed typical foliar injury to rice, egg plant, tomato and pepper and growth reductions in wheat, maize, radish and zucchini along with those showing foliar injury (Zheng *et. al.*, 1998).

## 2.3. BIO-MONITORING OF AIR POLLUTION

The Monitoring and assessment Research Centre, MRC, at King's College London- University of London, supported by United Nations Environment Programme, prepared and published a technical report on Biological of Environmental Contaminants Using Plants (Burton, 1986). This report highlighted in detail the increasing awareness of the effects of pollutants on plants and their potentials bio-monitors/ bio-indictors of air pollutants in the terrestrial environment.

Many plants and trees are so sensitive to certain pollutants that they behave like fingers on the pulse of nature. Such plant species are known as bio-indicators. The term "bio-indicators" is usually reserved for an organism that can be used to obtain qualitative information of its immediate environment, whereas the term "Bio-monitors" refers to an organism that can be used to obtain quantitative information. In both bio-indication and bio-monitoring, an organism responds to variation in the environmental conditions (e.g., with pollutants) by changing its mode of life in the morphological and/or metabolic-physiological way. Such changes can be monitored by observation or by measurement of elemental concentration (Franke C., and Studinger G., 1997 ; Nyarko, B.J.B., 2006).

Herbaceous plants are known suitable accumulation indicators of heavy metals. Most of these ruderal plants can be used for comparative evaluation of air pollution owing to their high resistance to pollutants and common occurrence.

Various organs of such plants contain different amount of elements. The highest quantities of trace elements are detected in roots and leaves, while stems and fruits (seeds) contain lower amounts. Composition of leaves indicates both soil and pollution (by subsequent uptake of bio-available pollutants load from the air. To study the endogenous elemental contents, the plant samples should be washed to eliminate the external contamination; otherwise commonly used washing procedure should be employed for air pollution load studies (Sumita N.M., *et al.,* 2004, Kucera, J. 1994; Kovacs M., 1992).

Bio-monitoring of air pollution has been found to be extremely useful to detect the kind and level of pollutants in air with and without measurement of air pollutants. In Bio-monotoring programme, the presence, absence, abundance, distribution, morphology and chemical characteristics of plants are used to arrive at a conclusion regarding air quality of that area (Dwivedy and Tripathy., 2007 & Prusty *et. al.,* 2005).

### 2.3.1. HEAVY METAL ACCUMULATION

The leaves of *Lolium perenne* and *L. multiflorum* have been reported to be suitable for multi-element monitoring. A positive correlation has been recorded between the chemical compositions of *Traxanum officinale* leaves and local pollution accumulation of the elements e.g. As, Br, Cd, Cr, Cu, Hg, Mn, Pb, Sb, Se, Zn (Kovacs M., 1992). Certain natural plants have been recognized especially suitable to indicate loading with selected elements, for instance, members of the *genus Thlaspi* for Ni and Zn, *Solidago canadensis* for F and Pb for Vanadium *Achilea milleforum, Amaranthus rotoflexus, Artemisia vulgaris, Calamagrostis epigeious, Conysa canadensis, Echinocholoa crus-galli, Plantago lanceolata,* while *Solidago graminifolia, Trifolium pretense* and *Zea mays* are accumulation indicators of organic pollutants, such as PCBs ( Buckley E.H., 1982).

If suitable plant does not occur in an area to be monitored, a standardized cultivated plant species grown in special pots (exposed container) and standard soil can be exposed at the site of the experiment for a definite period. *Lolium multiflorum* is one of the indicators used most frequently for this purpose (Kovacs M., 1992).Tree leaves absorb elemental pollutant both from the air and from the soil through roots.

The chemical composition of leaves varies with the seasons, especially of heavy metals, which is generally higher at the end of summer. Therefore, this season seems to be appropriate period of sampling. Many trees and shrubs have been particularly used for indicating selected elements even in trace and ultra trace levels (Huhn G., 1995), Loppi S., *et. al*., (1995), Madejón P., *et. al*., (2004) & DeFrança E.J., *et. al*., 2004).

Two of the recommended trees are *Populus nigra ssp. Italica (*Italian poplar*)* and *Robinia pseudoacacia* (the black locust tree) have found the widest application as Indicators of air pollution because of their resistance to pollutants and wide distribution throughout the world (Kovacs M., 1992). Coniferous trees are more sensitive indicators of air pollution than the deciduous trees, because they are exposed to air pollution over a longer period of time than leaves, due to longer life span of needles (3-4 years), except for *Larix deciduas*, which sheds all its needles each year. Thus most of the coniferous trees can accumulate large mass of pollutant, present even in a very low concentration (Loppi S., *et. al.*, 1995).

Various plant species grown in Pakistan have been studied to explore their potential for bio-mapping of far-reaching areas. Leaves of the most commonly grown trees such as *Broussonetia papyrifera* and *Populus* spp.have been investigated as they have a wide geographical distribution and grow in a wide range of habitats, which is also beneficial for comparative studies (Daud M., *et. al*., 2006).

The metals having anthropogenic origin (Al, Ba, Ca, Cd, Co, Cr, Cs, Fe, Hf, Hg, Mn, Nd, Sc, Se, Sm, Ta, Th, V, Yb and Zn) have higher concentration in roots and leaves, whereas the stem has minimum concentration of these metals. Similar observations have been reported showing that the metals accumulate more in roots and are scarcely translocated into above ground organ. The minimum concentration of the majority of metals in the stem of the *Asclepias procera* indicates that this part of the plant acts as a barrier to trans-located these elements from roots to leaves.

The higher metal contents in the leaves of *Asclepias procera* plant as compared to those in stems indicate that the absorption of metals from the environment / atmosphere occurs through the leaves. Similar observations have been reported for lead absorption by specific parts of the plants. It is, therefore, recommended that this part of the plant can be used to assess the extent of atmospheric pollution (Smith J.N., & Ellis, K. 1990; Madejón P., *et. al*., 2004).

A study on a bio-monitors to assess the atmospheric changes observed that in order to protect and rectify environmental damage, it is extremely appropriate to investigate all the factors leading to environmental pollution. Use of biological indicators was introduced about 30 years ago for intensive long term air pollution monitoring of vast area. Since then, a variety of organisms has been proposed for bio-monitoring purpose. The importance of particular bio-monitors can be inferred from the frequency of their use in various national and international programs. Researches show that numerous plant species have good potential of accumulating significant amount of pollutants. Adaptation of such reliable and inexpensive pollution-monitoring regime is quite useful as a regular practice for long term and far flung areas (Ahmad S., *et al.,* 2007).

A research worked on the basic criteria for selection of species as a bio-indicator. The high sensitivity of plants towards some pollutants means that a great variety of plants can be used as bio-indicators of heavy metals pollution in soil (Wenzel and Jockwer 1999, Namiesnik and Wardenski 2000, Chandhari and Gajghate 2000). Botanical materials have been used to detect the deposition, accumulation and distribution of metal pollution (Aksoy *et. al.,* 2000, Aksoy and Ozturk 1997; Rossini Oliva and Mingorance 2006), *Nerium oleander Quercus ilex* (Monaci *et. al*., 2000), *Robinia pseudoacacia* (Celik *et. al*., 2005), *Pinus pinea* (Mignorance and Olivia 2006), *Pyracantha coccinea* (Akguc *et. al.,* 2008), and *Murayya paniculata* are reported as bio-monitors for various heavy metal pollutants.

The different characteristics of foliar uptake, accumulation and translocation of atmospheric heavy metals by leaves, plant leaves are used as bio-indicators and/or bio-monitors of heavy metal pollution in the terrestrial environment (Tomasevic *et. al*., 2005).

Some plants can also be used as an active bio-monitor of heavy metal pollutions these are supposed to be an alternative to conventional instrumentation of environmental pollution control due to advantage such as allowing the monitoring of large area and to the low plant cultivation and maintenance cost (Calzoni *et. al.,* 2007). Bio-monitoring with plants is low-cost and valuable method to evaluating the effect of different air and environment pollutant (Oliva *et. al.,* 2006). *Nerium oleander (L.*) as a bio-monitor of lead and other heavy metal pollution in Mediterranean environments. Biological methods can replace with physical methods in the places that are limited to using to detect air pollution (Aksoy *et. al.,* 1997). Determining the heavy metal pollution in Denizli (Turkey) by using *Robinia pseudoacacia* Leaves (Celik, A *et. al.*, 2005).The, soil contamination with Zn, Ni and Cu caused by mine wastes and smelters are known to be phototoxic to sensitive plants (Chaney *et. al*., 1999).The binding to the cell wall is not the only plant mechanism responsible for metal immobilization into roots and subsequent inhibition of ion translocation to the shoot. Metals can also be complexed and sequestered in cellular structures (e.g., vacuole) becoming unavailable for translocation to the shoot (Lasat *et. al.*, 1998).

Copper occurs in the environment as hydrated ionic species, forming complex compounds with inorganic and organic legends. Copper causes injury at cellular level by the formation of free radicals. Cellular injury by this type of mechanism is well documented for copper as well as other metals (Shi *et. al.*, 1993); Gupta Kalra 2006). The growth of most plant species is adversely affected by tissue concentration of nickel above 50 mg kg-1 dry weight (Rahman and Mahmud., 2010). Soil contamination with Zn, Ni and Cu caused by mine wastes and smelters are known to be phototoxic to sensitive plants (Chaney *et. al*., 1999).

The lead (Pb), a potentially toxic heavy metal with no known biological function, has attracted more and more considerable attention for its widespread distribution and potential risk to the environment. Pb contamination in soils not only aroused the changes of soil microorganism and its activities and resulted in soil fertility deterioration but also directly affected the change of physiological indices and, furthermore, resulted in yield decline (Majer *et. al*., 2002).

The Cd accumulation in stem and inactivation in root cells are probably related to its binding in cell walls, compartmentalization in vacuoles and complexation with metal binding proteins and peptides, especially phytochelatin and metallothioneins. These processes are strategies employed by plants, at least in part, to face unavoidable stress conditions (Gupta and Goldsbrough., 1991). Abbasi S.A. *et al*., (1992) observed the increased introduction of foreign elements to the plant or excessive presence of some essential and trace elements can result in the toxicity of plant and hence change of colour of leaves, inhibition to the germination of seeds and growth of plants or even death of the plants.

The sensitivity of plants to heavy metals depends on an interrelated network of physiological and molecular mechanisms such as (i) uptake and accumulation of metals through binding to extracellular exudates and cell wall constituents; (ii) efflux of heavy metals from cytoplasm to extra-nuclear compartments including vacuoles; (iii) complexation of heavy metal ions inside the cell by various substances, for example, organic acids, amino acids, phytochelatins, and metallothioneins; (iv) accumulation of osmolytes and osmoprotectants and induction of antioxidative enzymes (v) activation or modification of plant metabolism to allow adequate functioning of metabolic pathways and rapid repair of damaged cell structures (Cho *et. al*., 2003).

Micronutrients such as Zn, Mn, Ni and Cu are essential for plant growth and development, high intracellular concentrations of these ions can be toxic. To deal with this potential stress, common non accumulator plants have evolved several mechanisms to control the homeostasis of intracellular ions. Such mechanisms include regulation of ion influx (stimulation of transporter activity at low intracellular ion supply, and inhibition at high concentrations), and extrusion of intracellular ions back into the external solution. Metal hyperaccumulator species, capable of taking up metals in the thousands of ppm, possess additional detoxification mechanisms. For example, research has shown that in *T. goesingense*, a Nickel (Ni) hyperacccumulator, high tolerance was due to Nickel (Ni) complexation by histidine which rendered the metal inactive (Krämer *et. al.*, 1997 & Krämer *et. al.*, 1996).

Cadmium treatment decreased height of soybean plant, number of branches, leaf area and dry weight of shoot/plant. In addition, photosynthetic pigments content in the leaves and carbohydrates concentration in the shoot, pod number/plant, seed weight (g)/plant and weight of 100 seeds (g) were also decreased. Whereas, Cd concentration in the shoot was increased and protein percent in the seeds was decreased. Regarding anatomical structure of soybean plant, cadmium treatment decreased stem diameter due to the decrements induced in the thickness of cortex, phloem, xylem and pith diameter as well as diameter of metaxylem vessels. Thickness of either leaflet blade or mesophyll tissues was decreased due to reducing induced in both palisade and spongy tissues thickness (Fouda and Arafa., 2002).

The uptake of Cd in different plant organs of spinach was parallel with Cd increments in root soil medium, and that associated with continuous reduction of spinach plant organs growth, in terms of leaf number, whole plant leaf area, fresh and dry weights of roots and shoots. Likewise, Fouda and Arafa (2002) showed that cadmium treatment decreased height of soybean plant, number of branches, leaf area and dry weight of shoot/plant. In addition, photosynthetic pigments content in the leaves and carbohydrates concentration in the shoot, pod number/plant, seed weight (g)/plant and weight of 100 seeds (g) were also decreased. Whereas, Cd concentration in the shoot was increased and protein percent in the seeds was decreased.

Cadmium negatively affected growth of tomato plant represented by plant height, leaf number, dry weight of shoots and roots. Water relations, photosynthetic pigments, carbohydrates and soluble sugars as well as fruit yield and quality were also negatively affected (El-Gamal and Hammad., 2003). Increased total soluble protein contents with low Cr concentrations (1 and 2 mM) may be due to disturbance in balance of functional part of protein in *Oryza sativa* plants under Cr stress (Singh *et. al.,* 2006). Total protein content decreased and was associated with leaf heavy metal content in soybean plants grown near a Pb-Zn-Cu mine (Onac., 2005).

Photosynthetic pigment content reduction by Cu, Pb, Zn, and Cd exposure was due to damage to the protein protochlorophyllide system. Thus, heavy metal accumulation in soil can reduce the chlorophyll content of tree and shrubs, planted in polluted area (Bayçu *et. al.,* 2006).The heavy metals such as Cu and Zn are essential for normal plant growth and development since they are constituents of many enzymes and other proteins. However, elevated concentrations of both essential and non-essential heavy metals in the soil can lead to toxicity symptoms and growth inhibition in most plants (Hall. J.L., 2002). The lifetime of active oxygen species within the cellular environment is determined by the antioxidant system, which provides crucial protection against oxidative damage. The anti-oxidative system comprises numerous enzymes and compounds of low molecular weight.

The heavy metals are known to interfere with chlorophyll synthesis either through direct inhibition of an enzymatic step or by inducing deficiency of an essential nutrient (Van Assche and Clíjsters., 1990). Heavy metals can be absorbed from the soil by plant roots and transported to leaves. In addition to roots, heavy metals are taken up from the air or foliar precipitation (Onder and Dursun., 2006). The metal uptake and deposition from the atmosphere to plant leaves may vary by leaf orientation, size, moisture level, leaf surface characteristics, and plant species (Mulgrew and Williams., 2000). Characterization of trace metal particles deposited on some deciduous tree leaves in an urban area. studied the different characteristics of foliar uptake, accumulation and translocation of atmospheric heavy metals by leaves, plant leaves are used as bio-indicators and/orbio-monitors of heavy metal pollution in the terrestrial environment (Aksoy and Ozturk 1997; Celik *et al*., 2005; Tomasevic *et. al.,* 2005).

The effects of Cd on the cell ultra structure of maize and showed that the grana cascade of chloroplast mitochondria decreased and/or disappeared under low concentration of Cd stress. Otherwise, the membranes began to decompose; the mitochondria also became tumerous and decomposed under high concentration of Cd stress (Peng and Wang., 1991). The grana also decomposed and some plastids were formed .In tobacco (*Nicotiana tabacum*), the photosynthetic membrane was damaged by Cd treatment, which might be the main reasons for the decreasing of photosynthetic (Jiang.,1995). Heavy metal contamination of soil affects the quality of crops, which very often reduces and sometimes disables the production of valuable food and animal feed. Cadmium is a heavy metal with a strong effect on crop quality (Das P., Samantarays *et. al.,* 1998). Moreover, it is a very mobile element in the environment. Plants can easily uptake cadmium and transfer it to other organs (Kabata-Pendias A., *et. al.,* 2001).

Growth on wheat plants exposed to cement dust pollution (Singh and Rao., 1980). Incidence of foliar injury symptoms and decrease in concentration of chlorophyll in plants in the vicinity of cement factories. Distorted wax, damaged stomata and disturbances in the ornamentation of cuticles in their SEM studies of leaf surface exposed to auto pollution (Verma and Singh., 2006).

Atmospheric aerosols have been receiving increased attention from investigation engaged (Das P., Samantarays *et. al.*, 1998) in air pollution and environmental hygiene studies. Size chemical compositions are among the most important parameter influencing the way in which air born particles interact with the environment. Air borne heavy metals mainly bound to particulate matter and only a small fraction (< 5%) is observed in vapour phase. Emissions from industrial establishment are one of the major sources of environmental pollution (Soni and Agrawal., 1997).The most obvious damage occurs in the leaves. The major damages caused by air pollutants to plants include chlorosis, necrosis and epinasty (Prasad and Choudhury., 1992). Vegetation is an effective indicator of the overall impact of air pollution. A large number of trees and shrubs have been identified and used as dust filters to check the rising urban dust pollution level (Rai *et. al*., 2009).

Gerendas *et. al.,*(1998) Studied that nickel (Ni) is an essential trace element in plants because of its important in the metalloenzyme urease, however, exposure to excessive nickel (Ni) can cause toxic effects on plants as in toxic effect on pollen germination (Levent Tuna *et. al.*, 2002) or in the inhibition of growth & many parameters of plants (Al-Jubouri, 2008). Zengin & Munzuroglu (2005) too, they showed inhibition of chlorophyll content with increasing concentrations of heavy metals. Chlorophyll content is often measured in plants in order to assess the impact of environmental stress, as changes in pigment content are linked to visual symptoms of plant illness & photosynthetic productivity**.** Lead (Pb) & Nickel (Ni) at 2.5mM increased in proline & decreased in protein content significantly. These results agreed with Panda (2003) who referred to increase the proline content in *Taxithellium* when treated it with low sp concentrations of some elements as ZnCl (0.001 µM (Panda., 2003). Dry weight of stem & leaf decreased by Pb at 10mM, whereas root dry weight decreased by all concentrations of heavy metals significantly (Miranda *et. al*., 2000).

These results reflect the toxicity effect of lead (Pb) at 10mM on the shoot, which is noticed by (Miranda *et. al*., 2000 & Nosalewics *et.al*., 2008) as well as, reflect the differentiation in metals accumulation & partitioning which is may be varied in parts of plant depending on type of metals. Effect of heavy metals on soil microbial community & mung beans Seed germination. Confirm that germination of seeds was gradually delayed in the presence of increasing concentrations of Lead

(Pb). At the same time, there are no significance changes in percentage of germination by Lead (Pb) & Nickel (Ni) at 2.5mM & by all concentrations of Co (Ashraf & Ali, 2007). Salt *et. al.*, (1995) observed that Lead (Pb) is a major environmental pollutant of worldwide concern. The toxic effects of Pb rest mainly in its ability to react with functional groups such as sulfhydryl, carboxyl & amine, leading to decrease or loss of activity of many enzymes that are important for cell functions.

### 2.3.2. AIR POLLUTION TOLERANCE INDEX (APTI) OF PLANT

The Air Pollution Tolerance Index (APTI), which is based on four biochemical properties of leaves, ascorbic acid(A), total chlorophyll(T), relative water content (R) and leaf extract pH(P). The formula of APTI is given as (Singh and Rao., 1983): APTI= [A (T+P) +R]/10

The study can be said that the deposition of atmospheric dust in plant leaves varies with structure, geometry, height, canopy of the tree. Smaller plants with short petioles and rough surface accumulate more dust than larger plants with long petioles and smoother leaf surface. The Air Pollution Tolerance Index (APTI) values estimated using the four biochemical parameters in plant leaves namely relative water content, chlorophyll, pH and ascorbic acid value can be used as a predictor of air quality. These parameters are significant in studies between plant environment interactions and used for development of tolerant & sensitive plants. The APTI of a particular geographical area can be used for Bio-monitoring air quality. The tolerant species and the species having more to collect dust can be used for green belt development in polluted areas (Thukar B.K. & Mishra P.C., 2010).

Agrawal & Agrawal, (1991) observed that sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_2$) are the most phytotoxic pollutants; these polluting gases enter leaves through stomata, following the same diffusion pathway as $CO_2$ (Zeiger, 2006). Sulfur dioxide occupies leading position as an air pollutant due to its potential hazard for vegetation as well as due to its wide distribution over the world has been reported to induce visible injury to leaves and leads to reduction in photosynthetic pigments inhibition of metabolic processes and suppression of growth and yield of plants of natural and agricultural ecosystems. In the cells, $SO_2$ dissolves to give bisulfite and sulfite ion Sulfite is toxic and at low concentrations it is metabolized by chloroplasts to sulfate, which is non toxic and at sufficiently low concentrations, bisulfite and sulfite are effectively detoxified by plants and $SO_2$ air pollution then provides a sulfur source for the plant (Zeiger, 2006).

Agrawal *et. al*., (1991) studied that Biomonotoring of air pollution around urban and industrial sites. They used the air pollution index (APTI) to examine the susceptibility of a number of plant species growing in an urban/industrial region of India. APTI considered levels of total chlorophyll, ascorbic acid, leaf pH and relative water content. Plants were classified into three categories of sensitivity: APTI $\leq$ 10, sensitive; APTI 10 - 16, intermediate; APTI $\geq$ 17, tolerant.

Higher ascorbic acid content of leaves might be an effective strategy to protect thylakoid membranes from oxidative damage under such water stress, as ascorbic acid is critically involved in the defense against ROS produced by the photosynthetic apparatus (Tambussi *et. al.*, 2000).

In this Study the APTI values for remaining species are reported lower and are considered as sensitive species. Further studies on air pollution tolerance index with respect to three industrial areas of South Bengaluru indicated that the air pollution was maximum in Jigani Industrial area and minimum in Electronic city. Studied leaf surfaces are most efficient at removing pollutants that are water soluble including sulfur dioxide, nitrogen dioxide and ozone. Pollutants travel through plants by translocation via the xylem and phloem.

Chemical pollutants absorbed by the leaves are trans-located to the root areas where they can be broken down by microbes in the soil and pollutants absorbed by the roots can be broken down and trans-located to the leaves where they are released into the atmosphere (Abida Begum *et. al.*, 2010). APTI increases from control site to polluted site improve the species tolerance to pollutions tress (Seyyednejad S.M., *et. al.*, 2011).

The ascorbic acid plays a role in cell wall synthesis, defense and cell division.It is also strong reducer and plays importants roles in photosynthesis carbon fixation, with the reducing power directly propotional to its concentration. So it has been given top priority and used as a multiplication factor in the formula.High pH may increase the efficiency of conversion from hexose suger to AA, while low leaf extract pH showed good correlation with sensitivity to air pollution (Escobedo *et. al*., 2008; Pasqualini *et. al*., 2001: Liu and Ding, (2008). The depletion in chlorophyll immediately causes a decrease in productivity of plant and subsequently plant exhibits poor vigor. Therefore, plants maintaining their chlorophyll even under polluted environment are said to be tolerant ones. The data obtained from detailed biochemical estimation of plant samples (including chlorophyll, ascorbic acid content. pH and relative water content), calculated the APTI (Singh and Verma., 2007).The lack of enough knowledge about resistant and sensitive species to air pollution has caused the field studies to identify sensitive and resistant species to air pollution (Prajapati *et. al*., 2008).

The effect of air pollution on some morphological and biochemical factors of *Callistemon citrinus* in petrochemical zone in South of Iran .The Study of air pollution effects on some physiology and morphological factors of *Albizia lebbeck* in high temperature condition in Khuzestan is done by Seyyednejad, S. M., Niknejad, M. and Yusefi, M., 2009. Precipitation samples were collected on event basis at Jawaharlal Nehru University, New Delhi during 1991. PH, major cations and anions of the samples were determined and the ionic balance was calculated in two consecutive months (August and September) during monsoon and the samples were found to be acidic. Although cations and anions decreased considerably, the hydrogen ion concentration increased with the increase of precipitation amounts during these months.

Winds blowing from industrial areas in the E. SE may be the possible cause for acid precipitation in this season (Ravichandran C, *et. al.,* 1994). Effects of lime kiln's air pollutants on some plants of Maihar region have been assessed. Results indicate the decreasing trend of dust deposition ($mg/cm^2$) on plant leaf surface with increasing distances from the emission source, in all four compass directions. Leaf washing suspensions of polluted site differed significantly for the values of pH, % Ca, %K and %Na from control site. Considerable differences in visual foliar injuries like chlorosis and necrosis have been observed between the leaves of polluted and control plants (Gupta AK *et al*., 1994).

Planted species were analyzed at various phyto-socio-economic as well as a few biochemical levels for certain vital parameters like photosynthetic pigments, relative water content, leaf extract pH, and ascorbic acid contents (Tiwari S *et. al.,* 1993). These plants have been graded on an arbitrary scale of 0-7-on the basis of their Expected Performance Index which is an expression of the total characterization of plant species with reference to its behaviour under polluted environment. The Sensitivity and response of plants to air pollutants is variable. The plant species which are more sensitive act as biological indicators of air pollution. The response of plants to air pollution at physiological and biochemical levels can be understood by analyzing the factors determining resistance and susceptibility (Lakshmi *et al.,* 2009). Using plants, as indicator of air pollution is the possibility of synergistic action of pollutants. Air pollution tolerance index is used by landscapers to select plants species tolerance air pollution (Agbaire, 2009).

Chlorophyll is the Principal photoreceptor in photosynthesis, its measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth (Joshi and Swami., 2009). Carotenoids are a class of natural fat-soluble pigments found principally in plants, algae and photosynthetic bacteria, where play a critical role in the photosynthetic process. They act as accessory pigments in higher plants. They are tougher than chlorophyll but much less efficient in light gathering, help the valuable but much fragile chlorophyll and protect chlorophyll from photoxidative destruction (Joshi *et. al*., 2009)

The studies on the effect of air pollution due to industrial activities on morphologic (leaf area, length of petiole and etc.) and physiologic (Proline, chlorophyll, soluble sugar content and etc.) factors of plants have been carried out. The physiological responses of forest trees to atmospheric pollution are well documented (Mclaughlin, S. B. 1994; Seyyednejad, S. M., Niknejad, M. and Yusefi, M. *et. al*., 2009). Higher ascorbic acid, contents of leaves might be an effective strategy to protect thylakoid membranes from oxidative damage under such water stress (Tambussi *et. al.,* 2000). Ascorbic acid is a strong reducer and plays important role in photosynthesis (carbon-dioxide fixation). Plants, the main green belt (GB) component, act as a sink and as living filters to minimize air pollution by absorption, adsorption, detoxification, accumulation and/or metabolization without sustaining serious foliar damage or decline in growth, thus improving air quality by providing oxygen to the atmosphere (Rawat and Banerjee, 1996; Beckett *et. al.*, 1998).

Chlorophyll content decreases due to production of reactive oxygen species (ROS) in the chloroplast under water stress (ROSs) are very small reactive molecules that can cause damage to cell structures during environmental stress (Tambussi *et al.*, 2000). Higher ascorbic acid content of leaves might be an effective strategy to protect thylakoid membranes from oxidative damage under such water stress, as ascorbic acid is critically involved in the defense against ROS produced by the photosynthetic apparatus (Smirnoff, 1996). Scholz and Reck (1977) have reported that in presence of an acidic pollutant, the leaf pH is lowered and the decline is greater in sensitive species. A shift in cell sap pH towards the acid side in presence of an acidic pollutant might decrease the efficiency of conversion of hexose sugar to ascorbic acid. However the reducing activity of ascorbic acid is pH dependent being more at higher and lesser at lower pH. Hence the leaf extract pH on the higher side gives tolerance to plants against pollution (Agrawal, 1988).

Plants have the potential to serve as excellent quantitative and qualitative indices of pollution. Since bio-monitoring of plants is an important tool to evaluate the impact of air pollution on plants, the *Mangifera indica, (L.,) Alstonia scholaris, Eupatorium odoratum,( L.,) and Hyptis suaveolens (L.,)* can be used as bio-monitors of vehicular pollution stress. Among the different plant species selected for this study, the tolerant plant species *Polyalthia longifolia, (Sonner*) among the trees and *Clerodendron infortunatum, L.,* among the shrubs can effectively be used in the air pollution amelioration purposes (Jissy S., Jyothi & D.S.Jaya., 2010).The plants with low APTI value were found only at the less polluted sites. The plants with higher APTI value were found to be resistant and were present at most of the sites. Resistant plants also act as a bio-accumulator for air pollutants as also reported by Prasanna *et. al.,(*2005). It is suggestible that the resistant plants marked in the investigation can be employed in abatement and control of air pollution. They can be grown in and around the coal fired industries to reduce the pollutants in air. Secondary benefit can be derived from them, as some are of high medicinal importance or fruit yielding. Reductions in leaf area and leaf number may be due to decreased leaf production rate and enhanced senescence. The reduced leaf area result in reduced absorbed radiations and subsequently in reduced photosynthetic rate (Tiwari *et. al*., 2006).

Chlorophyll and carotenoids is the main core of energy production in green plants, and their amounts are significantly by environmental effects on plant metabolism (Shweta M. and Agrawal S.B., 2006). Responses of plant species against same stress often are not similar. The effects of high sulphur dioxide level on three *Eucalyptus* species were very different depending on (Murray F., 2009). Sulphur or nitrogen dioxides ($SO_2$, $NO_2$) are the main pollutants in the polluted area, and acid rain is produced by their reaction with $O_2$ and water vapor. The materials entering the plants by acid rain cause reformation of chlorophyll to pheophytin, because $H^+$ can substitute $Mg^+$ in the chlorophyll molecule.

$$\text{Chlorophyll}+2H^+ \underline{\qquad\qquad} \text{Pheohytine} + mg^{++}$$

Occurrence of this process is strongly dependent on N content in leaf which in resistant plants reduces acid effect of $H^+$ from acid rain (Santi A., *et. al*., 2008). Increase in chlorophyll content has been reported as effect of low temperature. For example, activity of chlorophyll digestive enzymes in maize and wheat decreased due to reduction in air temperature. Not only the chlorophyll and carotenoid contents of the leaf but also the shape and direction of thylakoids may change in photoreactive stress (Sopher C. R. *et. al.*, 1999).

Reduction in leaf surface area and length of petiole causes less contact with environmental pollutants, especially air pollutants and improves resistance of plants against pollution. Reduction in leaf area of many plant species growing in the vicinity of heavy pollutants was observed. Some hidden injury or physiological disturbance might have occurred which caused reduction in morphological and anatomical characters of plant species. Leaf length is considered one of the characteristics, which reflect the ability of plant to protect against the stress. The results showed that the long-lasting impact of different pollutants including $SO_2$ and heavy metals causes a reduction in the leaf size and growth of nutritional status of plants as well as effects of various environmental factors (Seyyednejad S. M., *et. al.,* 2009).

Trees act as a sink for air pollutants and thus reduce their concentration in the air. Dust interception capacity of plants depends on their surface geometry, phyllotaxy, and leaf external characteristics such as hairs, cuticle etc., height, and canopy of trees. Removal of pollutants by plants from air is by three means, namely absorption by the leaves, deposition of particulates and aerosols over leaf surfaces, and fallout of particulates on the leeward side of the vegetation because of the slowing of the air movement (Tewari 1994 ; Rawat & Banerjee., 1996). Hope *et. al*., 1991; Auerbach *et. al.*, 1997) noticed that Limestone and cement dusts, with pH values of 9 or higher, may cause direct injury to leaf tissues (Vardaka *et. al.*, 1995) or indirect injury through alteration of soil pH.

The dust interception capacity of different leaves depends on leaf structure, phyllotaxy, presence/absence of hairs, presence of wax on leaf surface, size of petioles, and canopy structure. Plants with a waxy coating, rough leaf surfaces, and short petioles tend to accumulate more dust than plants with long petioles and smoother leaf surfaces. Dust particles affect leaf biochemical parameters, bringing about some morphological symptoms. The extent of such effects depends on plant tolerance toward dust particles and on the chemical nature of the dust. Decline in pigments may be because of a drop in pigment synthesis due to the shading effect of dust, the alkaline condition caused by dissolution of dust particles in cell sap that may lead to pigment degradation (due to photo bleaching), and/or the inhibition of enzymes essential for biosynthesis of pigments. All these changes exert stress on plant physiology (Santosh Kumar Prajapati and B. D. Tripathi., 2008).

Higher dust accumulation in *Dalbergia sissoo* may be due to rough leaf surface and small petioles that reduce movement of leaves in wind, while in the case of *Mangifera indica* and *Psidium guajava* it may be due to their waxy coating on leaves with slightly folded margin and rough surface, respectively. Lower dust accumulation in *F. religiosa* may be due to long petioles that help the leaves to flutter during wind, and the vertical position of the leaves which prevents dust retention.

Lower dust accumulation for *D. strictus* may be due to the thin lamina of their leaves and vertical position of the leaf. The influences of leaf characteristics on dust accumulation have also been studied (Vora and Bhatnagar (1986); Somashekar *et. al.,* (1999); Garg *et. al.,* (2000).The high dust accumulation in the winter season may be due to wet surfaces of leaves which help in capturing dust, with a gentle breeze and foggy condition preventing particulate dispersion. In the rainy season the least dust accumulation is reported because of washing of leaves and settling of particulates due to rain. Despite a high concentration of dust in summer, high wind speed may be the reason for the relatively lower dust accumulation in the summer than in winter (Santosh Kumar Prajapati and B. D. Tripathi (2008).

### 2.3.3. PROTEIN CONTENT IN LEAVES

Trees have long been known to act as a sink for air pollutants and to suffer from the harmful consequences. Reduction of ascorbic acid, protein, carbohydrate and pigments. Decrease in protein and carbohydrate content in petroleum–coke treated plants observed by many workers. In their experiment, initially chlorophyll was increased but later decreased (Prasad and Rao., 1981).The effect of stone crusher dust on grain characteristics of maize and found lower values of protein as compared to control (Pandey and Nand., 1995).Significant reduction in protein content in a few plants as a result of fly ash particulates (Trivedi and Singh., 1995) were observed that the considerable reduction in chlorophyll and protein content but an increase in sugar content in leaves of *Mangifera indica* and *Shorea robusta* affected by emissions from a nearby thermal power plant (Williams and Banerjee.,1995). Alterations in photosynthetic pigments and protein content in foliar tissues as a result of auto–exhaust pollution (Verma and Singh., 2006) was marked during research. Similarly, decrease in chlorophyll content as a result of increased dust deposition was noticed by Prajapati and Tripathi., (2008).

Foliar injury symptoms and weight (both fresh and dry) of leaves of *Abelmoschus esculantus* sprayed with cement dust, coal dust and fly ash at 2 $g/m^2$ day. They found chlorotic injury symptoms on cement and coal dust treated leaves. Foliar weight showed maximum reduction in case of cement dust–treated plants (Pawar *et. al.,* 1982). Reduction in leaf blade area of five tree species as a result of extensive dust and $SO_2$ pollution (Jahan and Iqbal.,1992). Most of the plants experience physiological alterations before morphological injury symptoms become visible on their leaves (Liu and Ding., 2008) was studied by there workers. Species–wise and season– wise dust deposition patterns on six selected tree species and their effects on chlorophyll and ascorbic acid content in foliar tissues (Prajapati and Tripathi., 2008) was studied by there workers. Ten annual plant species studies revealed that the foliar surface was an excellent receptor of atmospheric pollutants leading to a number of structural and functional changes (Rai *et. al,*. 2010).

The level of these pigments and the amount of total carbohydrate present in leaf tissue indicates the photosynthetic efficiency of these plants. Protein is the main component of protoplasm and a primary growth factor for all living creatures (Dulal Chandra Saha *et. al.,* 2011). The main constituent of all the enzymes required for different physiological processes is protein. The effectiveness of five tree species in capturing pollutant particles, Beckett *et. al.*, (2000) found that trees having finer, more complex structure of the foliage possessed greater effectiveness at capturing particles. The reduction in foliar chlorophyll and carbohydrate content in polluted sites which indicated that the process of manufacturing food by these trees was reduced as a result of air pollution. In both tree species concerned, foliar protein content was also found to be reduced in the highly polluted site as compared to the control. Testing the data of foliar chlorophyll, total carbohydrate and protein in both the trees in between control and polluted sites proved to be mostly significant (Dual Chandra Saha *et al.*, 2011) .The effects of leaf characteristics in terms of shape, surface area, presentation and cuticular texture on particulate accumulation (Pyatt and Haywood., 1989).

Trees are planted around industries and along road sides to absorb pollutants in air including particulate matter so as to reduce air pollution. Although trees possess some stress–tolerant mechanisms within them, considerable amount of damage is caused to them which are evident from this study showing physical damage of leaves as a result of dust deposition, inhibition of photosynthetic activities and protein synthesis as well as susceptibility to injuries caused by microorganisms and insects. Dustfall depends on SPM in the ambient air. Both the parameters (SPM and dust fall) contributed significantly to the degraded air quality at Lalpahari (Dulal Chandra Saha *et. al.,* 2011).

Plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. It reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Agbaire and Esiefarienrhe., 2009). Reductions in leaf area and leaf number may be due to decreased leaf production rate and enhanced senescence. The reduced leaf area result in reduced absorbed radiations and subsequently in reduced photosynthetic rate (Tiwari *et. al*., 2006).

Carbohydrate is an important storage and structural material for the plants. It is mainly produced in green leaves where mesophyll tissue is full of green pigments called chlorophylls. Chlorophyll a and b occur in higher plants, ferns and mosses. Therefore, the level of these pigments and the amount of total carbohydrate present in leaf tissue indicate the photosynthetic efficiency of these plants (Dulal Chandra Saha *et al.*, 2011). The effect of air pollutant exchange of gases on area of leaf of *Avicenia marine* deceased (Naido and Charicot., 2004).

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