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REVIEW

CHANGES IN BIOLOGICAL PARAMETERS OF TREES BY AIRBORNE POLLUTANTS

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Nowadays, air pollution is a very vital environmental issue. During rapid industrialization, anthropogenic activities result in a wide array of pollutants which are released to atmosphere and absorbed by the leaves of plants. Atmospheric pollutants have negative effects on woody plants. Airborne pollutants like oxides of sulphur (SO_x), oxides of nitrogen (NO_x), Ozone (O₃), particulate matter (PM), volatile organic compound (VOC), lead (Pb) can change the morphological, physiological and biochemical characteristics which can be deleterious in nature. Air pollution can dis-balance various enzymatic activities which can reduce various types of physiological processes such as, photosynthesis, respiration, transpiration but plants can scavenge and detoxify significant amounts of air pollutants which are effective in cleaning air. In the present paper, effects of different airborne pollutants on plants have been reviewed.

Keywords: air pollution, synergistic effect, physio-biochemical changes, sensitivity of plants, tolerant species

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ИЗМЕНЕНИЕ БИОЛОГИЧЕСКИХ ПАРАМЕТРОВ ДЕРЕВЬЕВ ПРИ АЭРОЗОЛЬНОМ ЗАГРЯЗНЕНИИ

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В настоящее время загрязнение воздуха является очень важной экологической проблемой. В ходе быстрой индустриализации антропогенная деятельность приводит к широкому спектру загрязняющих веществ, которые выбрасываются в атмосферу и поглощаются листьями растений. Атмосферные загрязнители действуют на древесные растения негативно. Такие загрязнители воздуха, как оксиды серы (SO_x), оксиды азота (NO_x), озон (O₃), твердые частицы (PM), летучие органические соединения (VOC), свинец (Pb), могут менять морфологические, физиологические и биохимические характеристики, что опасно по своей природе.

Загрязнение воздуха может нарушать баланс активности различных ферментов, что может приводить к снижению физиологических процессов различного типа, таких как фотосинтез, дыхание, транспирация, а растения могут поглощать и обезвреживать значительное количество загрязнений, что действительно для очистки воздуха. В настоящей работе был проведен обзор воздействия различных аэрозолей на растения.

Ключевые слова: загрязнение воздуха, синергетический эффект, физико-биохимические изменения, чувствительность растений, толерантность видов

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INTRODUCTION

Air pollution occurs by the addition of air pollutants into the atmosphere from various sources like vehicles, industries, domestic sources and natural sources, that change the composition of the elements present in the atmosphere and affect the biotic environment like animals as well as plant vegetation. Woody plants such as *Grevillea robusta*, *Rubus ellipticus* and *Debregeasia saeneb* [Sharma et al., 2019], *Alstonia scholaris* and *Nerium oleander* [Kaur et al., 2017] etc. play an important role in the removal of pollutants by absorbing and accumulating the pollutants in the plant parts. Air pollutants mainly two types that are of Primary air pollutants and secondary air pollutants. Primary air pollutants are the substances directly emitted from a process and secondary

air pollutants form in the air by the interaction or reactions between the primary air pollutants. Nowadays, primary and secondary air pollutants are continuously increasing due to industrialization and urbanisation. In this anthropogenic era, the concentration of greenhouse gases (GHG) of the atmosphere has been largely affected by human activities.

Atmospheric oxides of Nitrogen (NO_x), oxides of Sulphur (SO_x), Ozone (O₃) and Particulate Matter (PM), Volatile Organic Compound (VOC), lead (Pb) can be increased by release of toxic gases, by burning fossil fuels of power plant, automobiles and increasing vehicular traffic load which can give the plant vegetation a visible injury or can disbalance biological parameters such as physiological parameter and biochemical parameter like stomatal conductance, transpiration, photosynthesis, plant growth and ascorbic acid, protein, sugar contents, phenol content etc.

Air pollutants can induce morphological and anatomical changes [Sharma, 1997; Garg et al., 1980; Mishra, 1982]. Oxides of nitrogen and sulphur are known as primary air pollutants which are released into the air by combustion of fuels [Schwarze et al., 2006]. Nitrogen addition results in low productivity and increase in tree mortality [McNulty et al., 1996; Wallase et al., 2007] whereas sulphur can increase or decrease stomatal conductance [Unsworth et al., 1981]. Ozone (O₃) can affect the function of the membrane and reduce the rate of photosynthesis, which may lead to death [Lovett et al., 2009]. Particulate matter reduces the growth rate, flowering and reproduction rate [Sauders and Godzik, 1986]. Lead (Pb) can be absorbed and accumulated by plants parts which affects various physiological processes of plants negatively [Tripathi et al., 2010]. Deleterious effects of various types of airborne Volatile organic compounds (VOC) on plants also have been reported [Cape, 2003].

In this review, we have presented the account of physio-biochemical changes caused by air pollutants on the trees. It is noteworthy that air pollution may be exerting selective pressure on plant populations [Roose et al., 1982].

MATERIALS AND METHODS

Various databases on the internet such as PubMed, ScienceDirect, Directory of open access journals (DOAJ), JSTOR were accessed to search and download the information for the relevant literature. From those journals, important information has been studied and collected to complete this review.

RESULTS AND DISCUSSION

The different types of air pollutants and their effects are presented separately.

Effects of oxides of nitrogen and ammonia

Oxides of nitrogen (NO_x) are the mixture of nitrogen and Oxygen gases. These are Nitric acid (NO), nitrous Oxide (N₂O), nitrogen dioxide (NO₂). Nitric oxide (NO) is a colourless, odourless gas produced largely by fuel combustion at high temperature and nitrogen dioxide (NO₂) is reddish brown with sharp biting odour. Both nitric acid and nitrogen dioxide are precursors for tropospheric ozone (O₃) and they acts as greenhouse gases. In the presence of oxygen (O₂), nitric Oxide (NO) can be oxidised to form nitrogen dioxide (NO₂) in polluted atmosphere. Nitrogen dioxide (NO₂) in turn can react with a hydroxyl radical (•OH) to produce nitric acid (HNO₃). Ammonia (NH₃) is also an atmospheric Nitrogen species which reacts with the other pollutants, which are produced by NO_x emissions to produce fine particles of ammonium salts (NH₄).

Ammonia is produced by anthropogenic activity such as biomass burning, fertilizers, fossil fuel combustion. Oxides of nitrogen and ammonia, both have direct phyto-toxic effects at high concentrations [Bytnerowicz et al., 1999].

Nitrogen deposition can imbalance the nutrients of a plant [Barun et al., 2010]. Oxides of nitrogen (NO_x) can affect the chlorophyll molecules of leaves by oxides of nitrogen diffusion and formation of acid radicals in the leaf matrix which reacts with the cellular water [Raaja shramanian et al., 2011]. Oxides of nitrogen (NO_x) can deplete the soluble sugars in the leaves of plant which is grown in polluted area and that is corresponded with photosynthetic inhibition and stimulation of respiration [Tzvetkova and Kolarov, 1996]. In high concentration of nitrogen dioxide, acute foliar lesions and deformation has been observed in nitrogen dioxide sensitive plants and also in the form of visible injury such as yellowish dots on both surfaces of leaves occurs [Shrivastava et al., 1984]. NO_x compounds can reduce the growth rate and production of a plant as oxides of nitrogen directly affects the tissues of a leaf and also effect the structure of chemical substances [Badr, 1993]. High nitrogen dioxide can change the ultra-structure of chloroplasts which further affect the electron transport and reduce carbon dioxide (CO₂) [Mansfield, 1982]. At high concentrations of nitrogen dioxide, cell acidification occurs that leads to the generation of reactive oxygen species (ROS) which affects nitrogen assimilation and plant growth, sometimes leading to death [Sheng et al., 2019]. At high concentrations of ammonia primary effects such as reduction of photosynthesis, inhibition of stomatal conductance and inhibition of transpiration rate occur. Nutrient imbalance can also be induced by increased nitrogen content. Uncoupling of electron transport, membrane dysfunction has also been reported [Fangmeier et al., 1994]. In *Arnica montana*, visible symptoms on plant organ has been reported with high exposure of ammonia [Vander Eerden et al., 1990]. Visible foliar injury, even death of tissues between the veins occur during high exposure of ammonia [Krupa, 2003].

Effects of oxides of sulphur (SO_x)

Oxides of sulphur (SO_x) are the compounds, made up of sulphur and oxygen viz. Sulphur Dioxide (SO₂), Sulphur trioxide (SO₃) and particulate Sulphate (SO₄). Sulphur dioxide (SO₂), a colourless gas with a very sharp odour, is the predominant form that is found in the lower atmosphere. Sulphur di-oxide can be converted into Sulphur trioxide. In the presence of catalyst such as Nitrogen dioxide (NO₂), Sulphur dioxide can be oxidised and form a secondary air pollutant, Sulphuric Acid (H₂SO₄) and thus acid precipitation occurs [Anderson, 2005]. Sulphur dioxide is produced by natural sources like volcano, combustion of fossil fuels, burning coal, thermal power plants. Low concentrations of oxides of sulphur (SO_x) for long period may cause discolouration of leaves of the plant and at high concentrations of (SO_x), the leaf tissue can be damaged.

Sulphur dioxide exposure has a negative impact on the physiological, morphological and biochemical responses of the plant. Sulphur dioxide can diffuse and dissolve in mesophyll tissues and produces sulphite (SO₃²⁻) and bisulphite (NaHSO₃) ions which in turn is photo-oxidised to the less toxic SO₂²⁻ involving free radical reactions [Asada and Kiso, 1973] and those free oxygen radicals affect the cellular components including chlorophyll pigments [Shimazaki et al., 1980]. Leaf injury can be caused by high exposure of sulphur dioxide which leads to the reduction in photosynthetic activity and destruction of pigments which can cause stomatal damage affecting plant growth and yield [Tiwari et al., 2006; Otoide and Kayode, 2016]. During the detoxification reaction of Sulphite to Sulphate, reactive oxygen species (ROS) such as superoxide radical (O₂⁻)

and hydrogen peroxide (H_2O_2) also affects stomatal closure [Zhang et al., 2001]. Photosynthesis is also affected by high concentration of Sulphur dioxide as low concentration of Sulphur di-oxide increases Carbon dioxide (CO_2) and stimulation of hill reaction, but high concentration of sulphur dioxide competes with HCO_3 in carbon dioxide fixation resulting in the inhibition of photosynthesis [Knabe, 1976, Varshney et al., 1979]. In higher plants photorespiration is promoted by sulphur dioxide [Varshney et al., 1979]. Sulphur dioxide affects the energy metabolism by inhibiting the production of mitochondrial Adenosine tri Phosphate (ATP) which leads to reduced respiration of the plants [Malhotra et al., 1976]. At high concentration of sulphur dioxide thylakoid can be disrupted which leads to swelling and premature senescence of thylakoid [Knabe, 1976] which disturbs the electron transport chain (ETS) and results in the breakdown of physiological systems [Lee et al., 2017]. Sulphur dioxide also affects enzyme like Ribulose -1,5- di Phosphate Carboxylase (RuDP Carboxylase) by clipping the disulphide (S-S) bonds and results in the inactivation of the enzyme [Varshney et al., 1979]. Reactive oxygen species (ROS) is also increased by detoxification reaction of sulphite resulting in oxidative damage to nucleic acids, proteins and lipids [Mittler et al., 2004; Foyer and Noctor, 2005; Yi et al., 2005]. Acute level of sulphur dioxide interferes with nutrient uptake and plant growth which leads to the reduction in the length of roots, shoots, number of leaves, nodules and phytomass accumulation [Agrawal et al., 1985]. The inhibition of photosynthesis due to high sulphur dioxide can disbalance the reproductive process which leads to the reduction in the number of flowers and fruits [Hetherington and Woodward, 2003]. Sulphur dioxide affects carbon allocation, chlorophyll contents which further affect the growth and productivity of a plant [Treshow, 1984; Aminifar and Ramroudi, 2014; Singh et al., 2013].

Effects of ozone (O_3)

Tropospheric ozone, a secondary air pollutant is a greenhouse gas which is not emitted directly rather it is created by the photochemical and chemical reactions between the Oxides of Nitrogen (NO_x) and Volatile Organic Compounds (VOC) in the presence of sunlight and these reactions are accelerated by the emissions of pollutants from vehicles, industries, power plants and chemical plants in the presence of sunlight.

Ozone is considered as most phototoxic agent which results in plant anatomical, ultra-structural and photosynthetic changes and ultimately decline in growth and health of the tree [Sicard et al., 2011]. Chronic exposure of ozone affects the Net Primary Productivity (NPP) as well as reduce the gain of carbon by decreased carbon dioxide (CO_2) assimilation and increased reactive oxygen species (ROS) and thus altering the carbon allocation in plants which accelerates the senescence of plant [Elizabeth et al., 2012]. The oxidizing effect of ozone uptake increases the protein turnover and as a result foliar damage occurs [Bergmann et al., 1999]. High concentration of ozone showed a negative impact on the crown defoliation of *Pinus sylvestris* in Lithuania [Augustaitis et al., 2008]. Chlorotic mottles is a type of foliar injury, which is related to ozone levels was found in *Pinus halepensis* [Sanz et al., 2000]. Due to high exposure of ozone in the leaves of soybean, loss of chlorophyll, increased membrane permeability, decreased seed yield, loss of sulphydryl group and reduced soluble protein content was observed [Chernikova et al., 2000]. High concentration of ozone showed the reduction in the supply of carbohydrate in the roots which reduced the biomass of the root [Bytnerowicz and Gulke, 1992]. Ozone acts as a potent oxidant which helps in the reduction of photosynthesis [U.S. EPA., 2006]. High ozone exposure with drought stress showed the reduction of growth of mature woodland trees in Southern Britain

[Stribley and Ashmore, 2002]. The overall growth of a plant is negatively correlated with high concentration of ozone [Muzika et al. 2004]. Ozone leads to reduction in mRNA levels of both small (rbcS) and large (rbcL) subunits of RUBISCO in wheat [Sarkar et al., 2010]. Tropospheric ozone has been shown to incur deleterious effects in grassland and semi-natural vegetation which were noticed as reduction in crop yields, reduced forest biomass and altered species composition [Elizabeth et al., 2012].

Effects of particulate matters (PM)

Particulates, which is also known as particulate matter (PM), is a mixture of solid particles and liquid droplets that is suspended in the atmosphere. Particulate Matters (PM) are tiny particles that vary in size, chemical composition and concentration. Volcanoes, dust storms, forest fires, sea spray are the natural causes and burning of fossil fuels by vehicles, power plants, industries, construction sites and agricultural practices and mining are the man-made reasons. Particulate matter particles can be measured by their sizes viz. PM10 and PM2.5. PM10 are big particles with a diameter of 10 micrometer and smaller where as PM2.5 are fine particles with diameter of 2.5 micrometer and smaller. Some particulate matters according to their sizes are dust (size: 1 to 200 μm), smoke (size: 0.01 to 1 μm , which can be in liquid or solid state), fumes (size: 0.1 to 1 μm), mist (smaller than 10 μm , solid particles) and aerosols (smaller than 1 μm).

Plants, which are exposed to particulate matter, can be morphologically, physiologically and biochemically affected. On high exposure with particulate matter, two types of injuries can be seen in the leaves of plants – acute injury and chronic injury [Rai, 2016]. Foliar damages or injuries like necrosis, brown and yellow patches, black spots, even death of leaves have been reported as a result of high particulate matter exposure [Saha and Padhy, 2011]. Particulate matter can damage the stomata of leaves of sensitive plant species, can induce premature senescence which further decreases the photosynthetic activity of those species and also reduced permeability of membrane [Tiwari et al., 2006]. Fine particles of particulate matter can reduce the growth rate of a plant, which are sensitive to particulate matter [Bender et al., 2002]. On high exposure of particulate matter, photosynthetic pigments are degraded which inhibit the rate of photosynthesis [Chauhan and Joshi, 2008]. In *Zygophyllum prismatocarpum*, it has been reported that high exposure of limestone dust can cause the inhibition of carbon dioxide (CO_2) assimilation, uncoupling of oxygen evolving complex and decrease in Electron Transport Chain (ETS) [Van Heerden et al., 2007]. Biosynthesis of chlorophyll is also inhibited by particulate matter [Esmat, 1993]. Reactive Oxygen Species (ROS) can be produced due to exposure to particulate matter which leads to peroxidative destruction of fatty acids [Tiwari et al., 2006]. It has been reported that, degradation of chlorophyll content of leaves, protein synthesis is also affected [Baszynski et al., 1980]. The cycling of nutrients, which are necessary for the growth of plant can also be affected by particulate matter [Grantz et al., 2003].

Effects on volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) are carbon based chemicals which evaporate into the air at room temperature. VOCs can be divided into two categories of methane (CH_4) volatile organic compound and non-methane volatile organic compound (NMVOC). Methane is a greenhouse gas which is a major cause of global warming. When NMVOC reacts with oxides of nitrogen (NO_x), ground level ozone (O_3) is formed, which also results in climate change. Volatile organic compounds are found in paint, adhesives, solvents, textiles, cleaning products, electronic

equipments, building materials. Few examples volatile organic compounds include ethylene, xylene, benzene, toluene, sesquiterpene, polycyclic aromatic hydrocarbon (PAH), 1,3-butadiene.

Volatile organic compounds have been naturally found to occur in plant bodies which helps in ecological function, plant defence mechanism against insects, plant-plant communication, pollinator attraction and removal of reactive oxygen species (ROS) [Yuan, 2009]. Anthropogenic airborne volatile organic compounds are ubiquitous in nature and they can be captured by leaves and accumulated in the leaves of a plant [Brown et al., 1999]. Volatile organic compounds can damage the forest indirectly as volatile organic compounds have synergistic effects in them and act as damaging factor and in highly polluted area [Cape, 2003]. It has been reported that in young conifer trees, leaf surface waxes can be degraded by aromatic hydrocarbon fumes [Sauter and Pambor, 1989]. Short term acute exposure of volatile organic compounds has deleterious effects on sensitive plants. In *Phaseolus vulgaris*, pod weight had been decreased under acute exposure of volatile organic compounds [Cape, 2003]. In *Raphanus sativus*, epinasty, chlorosis in leaves and sepals, reduction in dry weight has been observed in laboratory experiment with exposure of ethylene (C_2H_4) [Van Haut et al., 1979] and in reduction in number of flowers per plant in *Avena sativa* has also been observed [Reid and Watson, 1985]. Visible injury, defoliation, fruit abscission have also been reported infield experiments of ethylene (C_2H_4) [Hall et al., 1957]. In the presence of Halon 1301 ($CBrF_3$), reduction in protein content has been observed in *Lepidium sativum* [Debus and Schröder, 2000]. Visible injury in *Lactuca sativa* has been reported subjected to high exposure of peroxyacetyl nitrate (PAN) [Sun and Huang, 1995]. Polycyclic aromatic hydrocarbon (PAH) can disbalance the physicochemical properties of membrane which results in the inhibition of photosynthesis and respiration process of sensitive plants species [Rai, 2016].

Effect of lead (Pb)

Lead (Pb) is a solid and highly toxic heavy metal. The sources of lead in urban area include exhaust of automobiles, chimney, factories, additives in pigments and gasoline, fertilizers, pesticides, metal plating, effluents from storage battery industry, melting and smelting of ores and urban soil waste [Sharma et al., 2005]. The primary anthropogenic source of airborne lead pollution is leaded gasoline, exhaust from vehicles. Gasoline additives, tetraethyl lead [$Pb(C_2H_5)_4$] penetrate into the atmosphere as unburned lead alkyl vapours and as lead halides.

Entry airborne lead depends on specific leaf morphology such as, downy leaves absorb heavy metals from the atmosphere [Godzik, 1993]. Lead (Pb) is a general protoplasmic poison whose reaction is cumulative, slow and subtle [Sharma et al., 2005]. Lead has no biological functions but can damage morphological, physiological and biochemical processes in plants. In high exposure of lead (Pb), visible injuries like chlorotic spots, necrotic lesions, leaf senescence occur to the lead sensitive plants [Patra et al., 2004]. Lead exposure can reduce the growth rate of leaves, decrease photosynthetic pigments, can also change the structure of chloroplast [Parys et al., 1998; Shearan and Singh, 1993]. Acute concentrations of lead can cause membrane lipid peroxidation changing the permeability of cell membrane [Nas et al., 2018]. Due to reduction in chlorophyll synthesis, electron transport chain and inhibition of enzymatic activities for carbon dioxide assimilation, stomatal closure of leaves of plants have been reported under lead pollution [Stefanov et al., 1995]. In sunflower, photosynthesis has been reported to be inhibited by high concentration of lead [Bazzaz et al., 1975]. Respiration process can also be affected by lead [Koeppel, 1977]. High concentration of lead can be the reason of reduction in transpiration intensity, osmotic pressure in cell sap [Parys et al., 1998]. At high concentration of lead can induce the production of Reactive

Oxygen Species like superoxide anion (O_2^-), hydrogen peroxide (H_2O_2), singlet oxygen (1O_2), which are very harmful at excess concentrations to plants [Sharma et al., 2005]. Lead can reduce the number of flowers in lead sensitive plants [Opeolu et al., 2010]. High concentration of lead can inhibit seed germination, reduce the growth of root and shoot, germination percent, germination index, dry mass of root and shoot [Mishra et al., 2006]. Cell death can occur in acute concentration of lead [Seregin et al., 2001].

Synergistic effect of air pollutants

In atmosphere, pollutants never occur individually. Airborne pollutants such as oxides of nitrogen (NO_x), oxides of sulphur (SO_x), ozone (O_3), volatile organic compounds (VOC), Particulate matter (PM), occur together in mixtures in different proportions and they interact with each other. The interactions between the pollutants are complex and non-linear. The effects of combined air pollutants differ from the effect of any single pollutant as synergistically, antagonistically or additively. The effects, antagonism, additive and synergism have been reported in experiment with combination of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3), which varies with plant species [Kostarik et al., 1993; Bucker et al., 1992]. Additive effect and antagonism have been reported in mixture of nitrogen dioxide and ozone [Adaros et al., 1991; Bender et al., 1991; Runeckles and Palme, 1987] and synergistic effect also have been reported [Ito et al., 1984; Runeckles and Palmer, 1987; Kostarik et al., 1993]. A combination of nitrogen dioxide and sulphur dioxide can be harmful to trees [Wellburn et al., 1981]. No foliar injury has been observed on exposure to nitrogen dioxide and sulphur dioxide individually where as mixture of these two gases caused severe damage in plants [Adaros et al., 1991]. Visible injuries have also been reported in the experiment of nitrogen dioxide and sulphur dioxide mixtures [Bennett et al., 1975]. The effects of nitrogen dioxide and sulphur dioxide are species specific and have additive effect [Bennett et al., 1995]. Synergistic effects of nitrogen dioxide and sulphur dioxide have been found in *Pisum sativum* by reducing vegetative and pod dry weight [WHO, 2000]. Deposition process of Sulphur (S) in plant can be enhanced when ammonia (NH_3) reacts with the acidifying effect of sulphur dioxide (SO_2) [Fowler et al., 2005]. When *Populus americana* was exposed to the mixture but ammonia enhance the photosynthesis individually, which shows the antagonistic effect of sulphur dioxide and ammonia [Van Hove et al., 1991]. The combination of sulphur dioxide and ammonia showed the synergistic effect in *Calluna vulgaris* by increasing the mortality rate. It has been reported that amount of ozone uptake can be increased in the presence of ammonia [Krupa, 2002]. No visible injury was observed when Douglas fir plants were exposed to ammonia and ozone individually whereas damage of epicuticular was observed in the combination of ammonia and ozone [Van der Eerden et al., 1994]. Along with increasing temperature, exposure of volatile organic compounds and oxides of nitrogen (NO_x) results in increasing ozone and its phytotoxic effects was observed in terms of reduced growth, photosynthetic rates of forest trees [Sicard et al., 2016]. Long-term exposure of ozone with elevated carbon dioxide (CO_2) can alter carbon cycling and may suppress gains in carbon sequestration [Karnosky et al., 2005; Long et al., 2004]. The effects of high carbon dioxide and ozone is a potential driving force of volatile organic compounds evolution [Penuelas and Llusia, 2003; Calfapietra et al., 2008]. The combination of ozone and sulphur dioxide showed various deleterious synergistic effects by damaging plants [Varshney et al., 1979]. Sulphur dioxide can control the toxicity of nitrogen dioxide in plants by inducing the enzyme nitrate reductase which reduces nitrogen dioxide to ammonia [Mansfield et al., 1982].

CONCLUSION

Industrialization and urbanization contribute various types of air pollutants in the atmosphere. Toxic gases are released by burning of fossil fuels from power plants and automobiles which leads to pollute the air of an area. Air pollution has deleterious impacts on plant vegetation. Airborne pollutants are absorbed by the leaves which act as a filter to protect the environment [Enete et al., 2013]. Air pollutants can dis-balance the morphological, physiological and biochemical parameters of plants due to their oxidizing potential. The sensitivity of plants to phytotoxic air pollutants can vary by the variety of plant species. In this review, the adverse effects of air pollutants: oxides of sulphur (SO_x), oxides of nitrogen (NO_x), ozone (O₃), particulate matters (PM), volatile organic compounds (VOC) and Lead, on trees has been discussed. High exposure of these air pollutants can not only increase morbidity but also mortality of plants. However, trees have a better way of adapting to the pollutants than human beings. In spite of adverse effects of these pollutants, there are a few reports on pollution tolerant plants [Singh et al. 1995; Varshney and Mitra 1995; Singh and Rao, 1983; Nivane et al. 2001], which can absorb, detoxify, metabolise and accumulate the pollutants to act as a living filter for the air pollution [Varshney 1985; Singh et al. 1995].

People need trees for their livelihood and well-being. Ecosystem needs trees as they for the 'lungs' of our planet. The recent incidents of Amazon and other forest fires such as in Australia and at Uttarakhand in India only shows how casual we are to our 'lungs'. Besides, It is well-known that, air pollution has significant impacts on biodiversity and ecosystem. In order To arrest the pollution we need to abolish the process of fossil fuel combustion or changing the pollution to less toxic form. Recently, cars have been developed with hybrid engines to combat this problem. However, changing our lifestyles and reducing ecological footprint requires action at the individual level for which awareness is an important step. Therefore, it is not solely the responsibility of Government and various agencies to control the pollution of phytotoxic pollutants by minimizing combustion process or by planting the pollutant tolerant species on polluted area as phytoremediation. All the people must follow their duty not to use too many cars and unnecessary electronic gadgets in order to reduce combustion. Besides, further research is needed for biomonitoring of these pollutant tolerant species to reduce the environmental pollution.

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