ASSESSMENT OF AIR POLLUTION BY USING BIOMARKERS IN PLANTS

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Abstract: Physical and chemical measurement of air pollutants provide a precise measure of pollutant exposure which is frequently used to predict the probable biological impacts. These pollutant concentrations can be measured accurately by using electronic equipment. But it is expensive and electricity consuming process. It is also requires experts to maintenance and operate. An alternative method to measure the intensity and type of the pollutant is to observe the injury caused by the pollutants as plants react to various pollutants and show certain changes in morphology and physiology. Injury caused by air pollution is repeatedly evident on plants before it can affect humans or other animals.

The use of biological indicators is a relatively new technique that scientists are increasingly relying on to measure the level of pollution. The existence of pollutants in the environment always represents a risk for living organisms. The concept of intoxication is related to specific organ alterations and clinical symptoms. Moreover, the relationship between the toxic levels within the organism and the toxic response is rather complex and has a difficult forecast since it depends on genetic and toxic kinetic factors.

A biomarker is the biological response that reveals the presence of the pollutants by the occurrence of typical symptoms or measurable responses. These individuals convey information on alterations in the environment or the quantity of environmental pollutants by changing in physiologically, chemically or behaviorally. Air pollution is aesthetically disgusting and can be a genuine health hazard to humans as well as to other organisms including plants. Past studies had revealed that air pollutants, particularly sulphur dioxide, led to a quantitive decrease in chlorophyll A and B pigments in some plants. The type and concentration of a pollutant can damage the tissue systems in plants and the damage symptoms produced in the plants are **specific** and depend on the concentration. Few reports reveal that urban pollution can affect the structural changes in leaf which may lead to lower photosynthesis. Therefore different plants can successfully be used as cheap and naturally available tools for the diagnosis of stress and the type of air pollution. The main focus of this review is to provide information about plant biomarkers and its use as indicators of air pollution so that early diagnosis is possible and possible prevention measures can be taken. This study will be useful for the policy makers and officials of air quality monitoring programmes.

Keywords: agriculture, industrialization, natural resources, pollution.

Introduction: Plants are main essential parts of ecosystem. They react rapidly to adverse environmental conditions ranging from invisible physiological, biochemical processes and visible morphological symptoms of injury. Biochemical biomarkers may be very specific for one or a group of pollutants or a general indication of an environmental stress.

Air pollution is the introduction of chemicals, particulate matter or biological materials that cause harm or discomfort to humans or other living organisms including plants. The most harmful air pollutants are sulfur dioxide (SO_2), nitrogen oxides (NOx), CO, troposphere ozone (O_3) and heavy metals, as well as suspended particulate matter which is identified as phytotoxic agents. Phytotoxicity of sulphur dioxide (SO_2) has been recognized for about a century , effects of ozone (O_3) for more than 30 years, acidic precipitation for almost 20 years, and effects of elevated levels of nitrogen compounds, nitrogen oxides (OX) and ammonia (NH_3) in the last decade. The other important pollutants such as peroxyacetyl nitrate (PAN) fluorides 20 or heavy metals are also known to be harmful. Air pollution is responsible for foliage injury and crop yield losses, are causing increased concern [1]. Urban air pollution is another serious problem in both developing and developed countries [2].

Earlier, air pollution was chiefly a problem of urban and industrial regions in the developed nations. But in the last three decades, changes in the pattern of air pollutant emissions (due to increase in motor vehicles and industries) have led to bigger pollutant impacts. The increasing number of industries and automobile vehicles are constantly adding toxic gases and other substances to the environment [3]. The substances mainly consist of sulpher and nitrogen oxides, CO, dirt particles, heavy metals, organic molecules and radio isotopes [4], [5]. It has been observed that ozone levels are higher in suburban and rural areas as compared to the urban areas, where as SO_2 and NO_2 concentrations are higher at urban sites [6]. Environmental stress, such as air pollution, is among the limiting factors which limit plant productivity and survivorship [7]. It is a major problem arising mainly from industrialization. It has

been observed that plants particularly growing in urban areas affected greatly due to varieties of xenobiotics (oxides of nitrogen and sulpher, hydrocarbon, ozone, particulate matters, hydrogen fluorides, peroxyacetyl nitrates(PAN) etc, [3]. It is known that air pollution can directly affect plants via leaves or indirectly via soil acidification. When exposed to airborne pollutants, most plants experienced physiological changes before visible damage to leaves [8]. High soil moisture and high relative humidity worsen SO_2 injury in plants [9]. Industrialization and automobiles are responsible for maximum amount of air pollutants and crop plants are very sensitive to gaseous and particulate pollutants [5].

Methodology: This research review paper is based on information from the fact sheets from NCBI, PMC [10] and EPA [11]. Information was also obtained from various web sites and articles addressing the air pollution. The selected references to the articles reviewed can be found in the references of the working document. Besides, many press releases have been reviewed on a regular basis. Meetings with local pollution control board and experts from various colleges and universities from Ujjain and Indore have also been a useful source of information. Information was also obtained from blogs, press releases, research centers and other private sources. Data and information was also gathered by personal meetings with experts and researchers.

Effect on leaf morphology The effect of air pollution on plants has been the subject of the concern. Many studies under laboratory and field conditions on different parameters have been examined at the leaf level, which are related with morphology [12], ultra structure [13], growth and development [14], photosynthesis [15], and chlorophyll fluorescence [16]. Most of their finding are obtained from laboratory studies and related with effects of individual pollutants on individual plants. But field studies with mixed gaseous pollutants are rare [15]. Barnes and Wellburn conducted experiments in the field in which plants are consistently exposed to complex mixtures of pollutants, which do vary both in time and space [17]. They found that pollutants can cause leaf injury, stomatal damage, premature sensences, decrease photosynthetic activity, disturb membrane permeability and reduce growth and yield in sensitive plant species [6],[17]. Reduction 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 [18],[6],[19] [3]. Bhatti and Iqbal [20] observed significant effects of automobile exhaust on the phenology, periodicity and productivity of road side tree species. The decrease in productivity and leaf area may be due to tolerance of water content tissue possible by decrease in leaf area [21].

Increase in length, breadth of leaf lets and decrease in area of leaf had demonstrated in leaves of *Albizia lebbeck* under the stress of air pollution [22]. Moreover, study on leaves of *Callistemon citrinus* planted in industrial region clears that length, breadth of leaf and also leaf area decreased [23], [24]. Chauhan et al [23]. observed significant differences in flowering, phenology and floral morphology in *Cassia siamia* plants growing at two different sites (polluted and non polluted) on two important roads of Agra city. Noormets et al [26] showed that stimulation of photosynthetic rates in elevated CO_2 was nullified by decreased leaf area. Totally describe of air pollution is related to leaf morphology is, reduction in leaf area, necrosis and chlorosis [27].

Effect on the pigments content: Plants that are persistently exposed to pollutants absorb, accumulate and integrate these pollutants into their systems. It is reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites [4]. Pollutants like SO_2, NO_2 and CO_2, when absorbed by the leaves may cause reduction in the concentration of photosynthetic pigments viz., chlorophyll, carotenoids which directly affected to the plant productivity [28]. Chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in metabolism and any reduction in chlorophyll content corresponds directly to plant growth.

Honour et al [29] has found relationship between traffic density and photosynthetic activity, stomata conductance, total chlorophyll content and leaf senescence. One of the most common impacts of air pollution is the gradual disappearance of chlorophyll and yellowing of leaves which may be associated with a consequent decrease in the capacity for photosynthesis [1]. Plants when are exposed to environmental pollution above the normal range photosynthesis gets inactivated. Even the distribution of plants diversity is highly dependent on the presence of air pollutants in the ambient air [28]. Agbaire and Esiefarienrhe [4] reported that certain pollutants can increase the total chlorophyll content while some others may decrease. Joshi and Swami [28] found that air pollution due to motor vehicle emissions in six different tree species caused changes in concentration of pigments. The deposition of suspended particulate matter on the leaf surfaces might be another factor that responsible for this decrease in the concentration of chlorophyll in

polluted area. Because particulate matter might block the stomata thus interfering the gaseous exchange which leads to increase in leaf temperature which may consequently retard chlorophyll synthesis [28].

A significant loss in total chlorophyll in the leaves of plants exposed to pollution supports the argument that the chloroplast is the primary site of attack by the air pollutants. The pollutants make their entrance into the tissues through the stomata and causes partial damage to the chloroplast and decrease other pigment contents. Tripathi and Gautam proved that high amount of gaseous SO_2 causes destruction of chlorophyll [29]. Several researchers have recorded reduction in chlorophyll content in leaves due to air pollution [6], [29], [1]. But on the contrary few researchers have reported an increase in chlorophyll content under air pollution. Tripathi and Gautam [29] reported that *Mangifera indica* leaves subjected to air pollution showed an increase in chlorophyll content. Agbarie and Esiefarienrhe [4] in a study have demonstrated that plants from polluted site contain more chlorophyll compared with those from non polluted area. Similarly, an increase in content of chlorophyll a, chl,b total chlorophyll and carotenoids in *Albizia lebbeck* and *Callistemon citrinus* has been reported by Seyyednejad et al [22],[31]. Yun [32] showed a reduction in photosynthesis because of the PSII function damage in tobacco. But plants exposed with 40, 80 and 120ppbv concentrations of O_3 exhibited a significant reduction in total chlorophyll content, RuBP carboxylase activity and net photosynthesis [33]. Joshi and Swami [1] have shown that the vehicular induced air pollution reduces the concentration of photosynthetic pigments in the trees exposed to road side pollution.

Carotenoids are the accessory pigments and protect the photosynthetic organisms and main pigments against potentially harmful photo oxidative process [28] [1]. Joshi and swami ([1] determined the concentration of carotenoids in the leaves of six different tree species and found a decrease in carotenoids content due to air pollution. Similar results were reported by several [5], [29], and [6].

Effect on Sugar: The concentration of soluble sugars is a sensitive indicator of the physiological activity of a plant and it determines the sensitivity of plants to air pollution. Plants manufacture sugars during photosynthesis and breakdown during respiration. Tripathi and Gautam [29] found a significant loss of soluble sugar in all tested species at polluted sites. Reduction in soluble sugar content in polluted stations can be credited to increased respiration and decreased CO_2 fixation and also due to decrease in chlorophyll content. Pollutants like SO_2, NO2 and H_2S under hardening conditions cause more depletion of soluble sugars [30], [29]. The reaction with sulfite with aldehydes and ketones of carbohydrates can also cause a reduction in sugars [34]. Moreover an increase in amount of soluble sugars as a protecting mechanism of leaves in Pinto bean [35], tree species [36] in *Albizia lebeck* and *Callistemon citrinus* [23] and in *Dodonea viscose* and *Prosopis juliflora* was observed [38], [24].

Ozone exposure reduced soluble sugars in pine needle was observed by Wilkinson and Barnes [37]. Consequently they increased frequently in association with foliar injury [35]. Reports from various researchers revealed that the resistant species to the air pollution showed more concentration of soluble sugars as compare to sensitive species [38], [39].

Effects on Proline: Proline is an amino acid and universal osmolytic element and essential for primary metabolism. It accumulates in plant body in response to several stresses and may have a role in plant defense reactions [40]. Proline acts as a free radical scavenger to protect plants away from damage by oxidative stress. [41]. Environmental stress (High and Low temperature, air and water pollution) can cause excessive Reactive Oxygen species (ROS) in plant cells which are extremely reactive and cytotoxic to all organisms [42]. Elevated exposure to air pollutants forces chloroplasts into an excessive excitation energy level, which in turn increases the generation of ROS and induces oxidative stress [43] and causes destruction of cellular constituents [6]. However, few reports revealed an increase in content of proline with increasing SO_2 concentration [9], heavy metals [41] and high salt [44] stress. But a significant increase in *Albizia lebbeck* has been reported by Seyyednejad et al [22].

There appears to be a relationship between lipid peroxidation and proline accumulation in plants subjected to diverse kinds of stress [41]. If such relationship exists, proline accumulation often occurs in a variety of plants in the presence of various stresses. This review article reveals that the effects of pollutants on plants mainly include pigment destruction, depletion of cellular lipids and peroxidation of poly unsaturated fatty acids and accumulation of proline [6].

Conclusions: Air pollution is one of the major problems world facing today. The active and bio-monitoring of air pollution carried out at urban sites have shown many major phytotoxic agents at levels above the threshold of plant damage. Air pollution injury to plants can be evident in several ways.

Air pollutants have a negative effect on the plants. They can have direct toxic effects on leaf structure and function or indirectly by affects a reduction in chlorophyll content. The particulate matters have a negative mechanical effect. They cover the leaf blade reducing light penetration and blocking the opening

of stomata. These impediments influence strongly the process of photosynthesis which rate declines sharply. Therefore plants can serve as inexpensive bioindicators and easy to diagnose the stress. Just by analyzing the visible parameters also, an early diagnosis of the intensity of pollution can be done.

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