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A REVIEW OF PLANTS PHYSIOLOGICAL RESPONSES TO AIR POLLUTION IN UNDER INDUSTRIAL AREA

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ABSTRACT

The most essential resource for life is air, and all living things require clean air to grow and develop in a healthy manner. Yet, industrialization has caused this air to become extremely polluted nowadays. Reduced biological and physiological responses of different plants in contaminated locations are caused by air pollution. As the species with the most potential to be impacted by ambient air pollution, plants are both an essential component of all ecosystems and the most prone to be damaged by airborne pollutants. This review shows how air pollution affects plant biochemical and physiological parameters.

Keywords: Air Pollution, Total Chlorophyll Content, Ph, Relative Water Content, Stomata.

I. INTRODUCTION

Depending on the industrial activities at a given site, a wide range of pollutants, including gases and dust emissions, are produced collectively by industrial pollution sources. Carbon dioxide (CO2), nitrogen oxides (NOx), sulphur dioxide (SO2), and carbon monoxide (CO) are examples of gaseous pollutants. In contrast, heavy metals like zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), nickel (Ni), mercury (Hg), cadmium (Cd), chromium (Cr), lead (Pb), and aluminium (Al) may be present in the composition of dust emissions. According to (Ncube et al., 2014), the majority of pollutants originating from industrial operations are aerodynamic, meaning that wind disperses them and deposits their constituents throughout the surrounding terrain. Plants can absorb gaseous pollutants and particle matter through their leaf stomata, cuticles, bark lenticels, and root hair.

Research indicates that plants' morphological (Ahmed et al., 2016; Leghari & Zaidi, 2013; Pourkhabbaz et al., 2010; Salam et al., 2016; Saleem et al., 2019), physiological (Gupta & Sarkar, 2016; Sen et al., 2017; Thakar & Mishra, 2010; Pourrut s2011), and biochemical (Seyyednejad et al., 2013; Wang et al., 2009; Woodward & Bennett, 2005) and biochemical properties are altered by exposure to air pollution. In the end, the development and productivity of plants growing in air-polluted environments are impacted by the alterations caused by pollutants. Koochak and Seyyednejad (2013).stated that the way in which plants react to environmental toxicities is determined by a variety of parameters, including the type of pollutant, the age and species of the plant, and the duration, intensity, and season of the exposure. According to Leghari and Zaidi (2013), the observed morphological and physiological changes point to the activation of strategic adaptation mechanisms aimed at reducing the harmful effects of toxicants in stressful environments.

Effect on Air pollution physiological parameter

According to Yan and Hui (2008) and (Escobedo et al., 2008), the following factors affect the accumulation of dust particles (pollutants): intermodal distance, petiole length, leaf area, orientation, margin, folding and arrangement, and hair density, type, and length. According to earlier studies, dust interception and retention are influenced by leaf orientation, age, surface roughness, and wettability (Beckett et al., 2000). According to Samal and Santra (2002), a plant's generally exposed parts, particularly its leaves, function as continuous absorbers of particulate matter. According to Prusty et al. (2005), larger plants with longer petioles and smoother leaf surfaces tend to acquire less dust than smaller plants with rougher leaf surfaces and shorter petioles. The detrimental effects of urban air pollution on plant leaf architecture have been shown by Sher and Hussain (2006). When studying the tansy plant, (Stevovic et al. 2010) found that the leaves from the contaminated site were noticeably thinner than the leaves from the uncontaminated area.

Effect on Air pollution biochemical parameter

According to Agbaire and Esiefarienrhe (2009), plants that are continuously exposed to environmental pollutants absorb, accumulate, and integrate these pollutants into their system. Depending on their sensitivity level, these plants may also exhibit visible changes, such as altered biochemical processes and the accumulation of specific metabolites. Variation in the biochemical parameters in leaves is utilised as a marker for physiological damage before the emergence of apparent injury symptoms or as a sign of air pollution for early stress diagnosis (Tripathi et al., 2009).

Effect of Air Pollution on Relative Water Content

The amount of water a plant contains when it is unable to absorb further water is known as its relative water content, or RWC. We refer to this condition as full saturation. This condition is not necessary for a plant to live. In any case, one method for determining whether a plant is stressed is to find out how much water it can store. When a plant is under stress, like when it is exposed to air pollution, its high water content within the plant body maintains its physiological equilibrium since transpiration rates are often high. Plants with high RWC are more resistant to drought. Plants cannot survive well if the air pollution reduces the rate of leaf transpiration because they would lose the motor that draws water up from the roots for photosynthesis (1%–2% of the total). At that time, the plants stop cooling the leaf and stop transporting minerals from the roots to the leaf, where biosynthesis takes place (Liu, Y.J. and H. Ding, 2008). Several physiological factors, including as leaf turgor, development, stomatal conductance, transpiration, photosynthesis, and respiration, influence the water status of leaves. When RWC is low, the relative water content shows a shift in the hydration state of the leaf grid and will result in a higher acridity condition. Causticity will be lessened by more water (Palit, et al., 2013). According to Agrawal and Tiwari (1997), the protoplasmic porousness of cells in relation to relative water content results in water loss and supplement breakage, which causes leaves to senesce promptly.

Effect of Air Pollution on the Leaf Extract pH

The pH of the concentrates made from the plant's leaves is called leaf extract pH. In plants, photosynthesis is reduced when the pH of the leaves is low. (H. Ding and Y.J. Liu, 2008). While plants with a pH of about 7 are more resistant, those with a lower pH are more vulnerable to air pollution (Singh SN, Verma A 2007). The pH of leaves decreases significantly in sensitive species when they are near acidic contaminants (Paulsamy et al., 2000). As a result, the higher pH of the leaves gives the species resilience against pollution. (Sck, S., and Scholz, F. 1977). Have documented that the pH of leaves decreases in the presence of acidic pollutants, with the decrease being more pronounced in sensitive species. Relative to an acidic pollutant, a shift in the pH of cell sap towards the acidic side may reduce the rate at which hexose sugar is converted to ascorbic acid. A few biochemical parameters were used to examine the relationship between visible and hidden injury. The results indicated that total phenol content increased as a result of air pollution impact, pH of the leaf wash and cell sap decreased due to the presence of pollutants, which are acidic in nature, and pH of the wash and sap increased with increasing distance from pollution sources (Pawar, et al., 2010).

Effect of Air pollution on Chlorophyll

One of the most important components of green plants' energy generation is chlorophyll, and the amount of this component is highly influenced by the state of the environment. Plant productivity declines as a result of chlorophyll depletion, and as a result, plants lose vigour. Under stressful conditions, plants lose some of their total chlorophyll content (Speeding and Thomas 1973). (Bell and Mudd 1976) suggested that the production of chlorophyll degradation may be connected to a plant's ability to withstand SO2. Nonetheless, it is believed that plants that retain their chlorophyll in the face of pollution are tolerant (Singh and Verma 2007).

Because chlorophyll is essential to plant metabolism, measuring it is a useful method for assessing how air pollution affect plants. Plant growth is immediately impacted by any decrease in chlorophyll content (Agbaire and Esiefarienhre 2009). One often used measure of how rising air pollution affects plant development is the net photosynthetic rate (Woo et al., 2007). Stress from air pollution causes stomatal closure, which lowers leaf CO2 availability and prevents carbon fixation. Some of the air pollutants that are absorbed by plant leaves include sulphur dioxides, nitrogen dioxides, and CO2. These pollutants cause a decrease in the levels of photosynthetic pigments, such as chlorophyll and carotenoids, which directly affects plant productivity (Joshi and Swami 2009; Honour et al., 2009).

Rao and LeBlanc (1965) discovered that lichens exposed to high concentrations of gaseous SOx (5 ppm for 24 hours) experienced chlorophyll degradation. Chlorophyll molecules were broken down into pheophytin and Mg^{2+} at this high concentration. With acids or other acidic chemicals, chlorophyll can be converted in a manner similar to that of pheophytin. During this process, two hydrogen atoms take the place of Mg^{2+} in the chlorophyll molecule, altering the molecule's light-spectrum properties. Free radicals generated during the oxidation of HSO_3-catalyzed breakdown of linoleic acid hydrogen peroxide can also cause rapid in vitro degradation of chlorophyll (Peiser and Yang 1977, 1979). Evidence was published by (Shimazaki et al., 1980) showing that SO_2 fumigation of leaves enhances O_2 - production in chloroplasts, which degrades chlorophylls. It has been demonstrated that at very low concentrations (10^{-8} to 10^{-7} M), a superoxide radical affects chlorophyll (Asada et al.,1977). Gaseous SO_2 degraded chlorophyll an in Spinacia oleracea leaves more quickly than chlorophyll b, but pheophytin a did not rise in proportion to the loss of chlorophyll a (Shimazaki et al., 1980). It was proposed that SO_2 primarily damages chlorophyll through a free-radical oxidation since scavengers of free radicals reduced the breakdown of chlorophyll in Spinacia oleracea leaves. The finding that superoxide dismutase prevented the degradation of chlorophyll a provided additional evidence for this. According to Shimazaki et al., (1980), sulphur dioxide suppresses superoxide dismutase activity in fumigated tissues. Moreover, the free-radical oxidation of chlorophyll was linked to the increase of malondialdehyde, a lipid peroxidation product, and a reduction in chlorophyll an in Spinacia oleracea leaves fumigated with SO_2.

Effect of Air pollution on stomatal

According to (Verma et al., 2006), stomatal compression fluctuation is a vital mechanism for controlling the absorption of contaminants and a reaction to environmental stressors. Plant species may have evolved a physiological response to cope with the unfavourable environmental conditions brought about by the high level of pollution in the area, which involves an increase in the number of stomatal cells on the surface of their leaves (Sukumaran, 2014). According to Sukumaran (2014), plants in contaminated locations have a large increase in stomata, which may be an adaptive trait to lessen the harm that air pollutants cause. The findings of the (Rai et al., 2004) study also demonstrated that in contaminated areas, the stomata on Terminalia arjuna and Quisquali indica plants expanded. They claimed that some plants are developing more stomata to fend off air pollution.

Microscopic tests conducted by Sharma and Butler (1973) have revealed a slight decrease in the pore size of the stoma in plants cultivated in contaminated locations. Their findings suggest that plants in contaminated locations may have adapted appropriately by shrinking the size of their stomata, which could lessen the amount of toxins that are absorbed. Research has demonstrated that the pore length of the stoma in Ixora coccinia and Muntingia calabura plants in urban contaminated areas was shorter than that of control plants (Thara et al., 2015).

According to studies on the role of stomata in shielding plants from air contaminants, plants can better defend themselves from harm from the atmosphere when their stomata are closed (Majernik and Mansfield, 1970). Other cells within the leaf are shielded from impurities when the stomata are closed. However, the effect is likely to be severe and the plants' subsequent growth will be impacted if the stomata close permanently (for example, if the guard cells are damaged and unable to regenerate). This is because the primary pathway for absorbing carbon dioxide for photosynthesis will be blocked (Majernik and Mansfield, 1970).

According to a study, the stress of pollution caused the stomata in Boerhaavia, Amaranthus, and Cephalandra to simply close, and the stomata in Nerium plants and Tabernaemonatana leaves to clog (Mandal, 2006). According to (Amulya et al., 2015), there was a significant difference in the number of closed and open stomata between the polluted and control areas. The contaminated region had more closed stomata than the control area.

II. CONCLUSION

Air pollution profoundly impacts plant physiology and biochemistry, altering parameters such as chlorophyll content, pH levels, relative water content, and stomatal behavior. These changes, influenced by various pollutants, highlight the vulnerability of plants to airborne contaminants and emphasize the importance of mitigating industrial pollution to safeguard plant health and ecosystem stability.

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