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Biomonitoring with special reference to visible damages in different plant species due to air pollution – A review

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ABSTRACT

Air pollution is a matter of great concern in the globe. Generally air pollutant generates from industries, automobiles, etc. and the primary pollutants may easily convert to secondary pollutants. Both of these pose serious threat to the plant community viz. crops, vegetables and avenue plant species are depending on the emission pattern, atmospheric transport and leaf uptake and on the plant's biochemical defense capacity. An impact caused by air pollutants depends not only upon its concentration, but also on the duration (acute and chronic exposure) and combination of air pollutants. Biomonitoring on plant species is an easy tool to know bioindicator species in which exposure of air pollutants can easily be identified. The present review deals with past and present research works of major gaseous pollutants emissions and their impact on crop, vegetables and tree species performance from available literatures.

***Keywords*:** Air pollution; Biomonitoring; Crops and vegetables; Avenue tress; Bioindicators

1. INTRODUCTION

Biomonitoring, or biological monitoring, is generally defined as "the systematic use of living organisms or their responses to determine the condition or changes of the environment" (Gerhardt, 1999). Biomonitoring determines of the use of responses of individual plants or plant associations at several levels in order to detect or predict health of the environment. When some plant species are sensitive to single pollutants or to mixtures of pollutants then these species are used to monitor the effects of air pollutants as bioindicator plants. These plants are potent to show morphological visible injuries in their leaves as foliar injuries and growth retardation by the effects of phytotoxic compounds present in ambient air. Biomonitoring of air pollution with plants has been a common practice for many decades and throughout the 1990s WHO collaborated studies have already been performed. The ambient air pollution causes by industries, automobiles and other fume generations (Rahlenbeck, 1991; Flagler, 1998; Mulgrew and Williams, 2000; Zimmermann et al., 2000). The biological indicators gain effects-related information which cannot be assessed by means of chemical analytical methods of air pollution monitoring systems.

Many studies as bioindicator plants showing visible leaf injuries and morphological anomalies related to air pollution have been studied by many countries of the globe (Middleton et al., 1956; Bull and Mansfield, 1974; Husen et al., 1999; Naveed et al., 2010; Seyyed and Koochak 2011) as well as many parts of India including Kolkata (Tiwary et al., 2008; Saquib et al., 2010; Rai et al., 2011; Deepalakshmi, 2013; Nandy et al., 2014).

The present review aims to compile different literatures on biomonitoring with special reference to visible injuries of leaves in plant species due to air pollution.

2. IDENTIFICATION OF AIR POLLUTION BIOINDICATOR PLANT SPECIES SHOWING VISIBLE INJURIES IN LEAVES AND GROWTH PATTERN

Bioindicators as an indicative organisms have already been established and differentiated into response and accumulation indicators. The response or sensitive indicator indicates distinctive effects as foliar injury upon the exposure to a gas while accumulation or tolerant indicators indicate enhanced concentrations of a chemical compound(s) without exhibiting a decreased vitality. Biomonitoring as a tool and the differentiation between sensitive and tolerant, different approaches have been followed. Other references on general principles of bioindication and biomonitoring as well as on general plant responses to air pollution are given by many researchers (Rao, 1992; Agarwal et al., 1997; Bell and Treshow, 2002; Markert et al., 2003; Nandy et al., 2014).

2. 1. Crops, vegetables and trees damage by air pollution

According to Rai et al. (2011), the urban air pollution may be a serious threat to agricultural productivity in areas around urban centers and there exist variations in pattern of pollutants due to interactions during transport on the trend of emissions and concentrations of major gaseous pollutants viz. SO_2, NO_2 and secondary pollutant O_3 and their effects on agricultural crops and avenue trees (Nandy et al., 2014). Air pollutants can produce a wide range of visible symptoms (acute injury) on crops, vegetables and trees. Ghouse and Khan (1984) have reported the growth response effect in vegetables by air pollution. Injury to plants as a result of pollutants has been classified as either chronic or acute effect. The damages lead to effect on agriculture as well as different tree species by air pollution, which is an issue of national concern (Agrawal, 2005; Choudhury and Banerjee, 2009).

Ashmore and Marshall, (1999) have reported that it was found severely impacts on agriculture by ozone, which is an issue of global concern. It was noted that the crop *Achyranthes aspera* Linn. showed the effect on morphology and some functions under air pollution stress (Dhir et al. 1999). It was also reported that the growth and reproductive behaviour has been changed in mustard by air pollution (Saquib and Khan, 1999).

According to Nighat and Mahmooduzzafar (2000), the stomatal conductance, photosynthetic rate and pigment content in *Ruellia tuberose* leaves as affected by coal-smoke pollution.

Legge and Krupa (2002) have studied an 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 chlorotic streaks with occasional reddish pigmentation. They have also studied 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. Wu and Tiedmann, (2002) have studied to showed an evidence for oxidative stress involved in physiological leaf spot formation in barley during winter and spring season.

Morgan et al. (2003) have studied a meta-analysis of photosynthesis, growth and yield impact in soybean by elevated ozone exposure. It was also reported that ozone injury on cutleaf conefower (*Rudbeckia laciniata*) and crown-beard (*Verbesina occidentalis*) in Great Smokey Mountains National Park (Chappelka, et al., 2003).

Ashmore, (2005) has reported that O_3 is a causative agents to damage the agricultural crops. When the effect is severe, death of plant organ may occur as well as effects on cells and organs, affect plant growth, which ultimately leads to yield reductions (product synthesis) and quality changes.

Agrawal et al., (2006) have studied the effect of air pollution on yield and quality of mungbean grown in periurban areas of Varanasi. India. In the work by Tiwari et al., (2006), ambient air pollution impacted on carrot plants at a suburban site using open top chamber. Also it was noted that the 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).

According to Black et al., (2007) and Biswas et al., (2007), it was found that the impact of O_3 was known to vary between species and cultivars. According to Rai et al., (2007), in their observation, in an open top chamber study conducted at suburban site in Varanasi, India found 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, O_3 42.1 ppb).

Heath (2008) has reported that the initial site of injury caused by O_3 and /or O_3 generated ROS is the plasma membrane, resulting in changes in permeability, fluidity, etc. It was reported the rice production in a changing climate, a meta-analysis was done of responses to elevated carbon dioxide and elevated ozone concentration (Ainsworth, 2008). It was found 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 air (Rai and Agrawal, 2008). As per Saquib (2008), it was observed that the biomass and chlorophyll pigment of *Brassica juncea* has altered due to coal-smoke pollution.

Singh, et al., (2009) have reported that the physiological, growth and yield responses of a tropical oil crop (*Brassica campestris* L. var. Kranti) under ambient ozone pollution at varying NPK levels. Saquib (2009) has also reported the root growth responses of *Melilotus indicus* (L.) due to air pollution.

Chauhan and Joshi (2010) have documented in a field transect study at Haridwar, India that higher load of air pollution (SO_2 6.5 ppb and NO_2 9 ppb) showed maximum reductions in growth and yield to wheat and mustard crops.

Rai et al., (2011) have reported that air pollutants pose risks on yield of crops depending on the emission pattern, atmospheric transport and leaf uptake and on the plant's biochemical defense capacity.

Ozone as an air pollutant is well-documented to reduce crop yields in the densely populated Indo-Gangetic Plain, there was little knowledge of its effects in other parts of south Asia. Researchers have surveyed crops close to the city of Peshawar, in north-west Pakistan, for visible injury by ozone concentrations. Foliar injury was found on potato, onion and cotton. It was reported ozone may be a significant threat to sensitive crops (Ahmad et al., 2013).

Researchers have examined the correlation between per capita number of state-monitored enterprises and other socio-economic indices to show the negative impacts of sulphur dioxide (SO_2) industrial air pollution on agricultural development in the regions (Wei et al., 2014). Nandy et al. (2014) have also studied the adverse effects mainly morphological damages viz. L (Length), B (Breadth) and L/B ratio was found significantly increasing and decreasing trends and visible injuries such as necrosis, chlorosis, pigmentation and burning were observed in an increasing as well as decreasing trends by automobile air pollution in four selected common roadside plant species such as *Ficus bengalensis*, *Alstonia scholaris*, *Neolamarckia cadamba* and *Ficus religiosa*, which may be the effects of individual and/or combination of air pollutants.

3. DISCUSSION AND CONCLUSION

The published results presented here clearly reveal that air pollution causes visible injuries and changes in growth and development in crops, vegetable and tress at acute and chronic exposure. From the previous research works in globe, the concentrations of phytotoxic air pollutants often exceed the toxic limits (CPCB, 2009; Wei et al., 2014) by industrial and/or automobile exposures. The biomonitoring study has already been prescribed by Ministry of Environment and Forests (MoEF), Government of India and this biomonitoring study in plants with special reference to visible injuries and growth pattern of any plant is a very easy tool to detect specific impacts of air pollutants as well as biological monitoring to know exact load of industrial and/or automobiles air pollution.

In the present review, it was concluded that biomonitoring study with special reference to visible injuries and growth patterns in crops, vegetables and trees is an easy tool for the detection of air pollution load at roadside exposure by automobiles as well as air pollution in industrial vicinity. This present review will also help for further research in different plant species exposed to air pollutants because of compilation of selected literatures author has presented here.

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