Name of Ph.D. Scholar : Sami Ullah Qadir

Name of Supervisor : Prof. Weqar Ahmad Siddiqui

Title of the Ph.D. : Effect of Fly ash on some Micromorphological, Biochemical, and Phytochemical components of *Pithecellobium dulce* (Roxb) Benth. and *Azadirachta indica* (A. Juss).

Abstract

Fly ash (FA) is a coal combustion residue generated in bulk amounts from coal combustion in thermal power plants. It has been recognized as a serious threat to biotic and abiotic components of our environment. Safe disposal and management of FA is a huge challenge to ecologists throughout the world. Hazardous FA dumpsites on the surface of the earth are a great source of pollutants including toxic metals, and polycyclic aromatic hydrocarbons. Thus, FA contaminates both terrestrial and aquatic ecosystem all over the globe. Interactions between plants and FA are very complex. Low concentrations of FA enhance plant growth, but higher concentrations draw the toxic effects. The deposition of FA on plant leaves growing near FA dumpsites affected the stomatal functioning, photosynthesis, and transpiration. Under FA effect, decline in stomatal conductance was recorded, that leads to a drop in the net photosynthetic rate and an increase in the internal CO_2 concentration of leaves of both the plant species. Considerable reduction in pigments (chlorophyll *a*, chlorophyll *b* and carotenoids), and total chlorophyll was observed at fly ash dumping site. Fly ash stress revealed the inhibitory effect on Nitrate reductase activity (NRA), Nitrate, soluble protein, and reducing sugar content, whereas stimulatory effect was found for the stomatal index, nitrogen, proline, antioxidants and sulphur content in the leaves. Under fly ash stress, stomatal conductance was low, leading to decrease in the photosynthetic rate and increase in the internal CO_2 concentration of leaf. Single leaf area (SLA), leaf length and leaf width also showed a declining trend from control to the polluted site in both the plant species.

This study further revealed that fly ash contributed high levels of trace elements in soils contaminated with it and subsequent higher accumulation in aboveground plant parts. Because of the widespread occurrence of heavy metals in the environment, their residues

also reach and assimilate in plants. A Higher level of metal accumulation in plant parts especially in roots and shoots of two different medicinal plant species (*P. dulce* and *A. indica)* of India showed metal biomagnification and thus act as bioaccumlator species. Great care should be taken when these plant species are used for medicinal purpose for curing various human diseases as they can lead to metal toxicity in humans when present in above permissible levels.

Reactive oxygen species (ROS) are highly reactive in nature because they can interact with many other molecules and metabolites such as DNA, pigments, proteins, lipids, and other essential molecules which lead to series of cellular destructive processes, thereby disturbing plant physiological activity and impeding plant growth and development. The antioxidant enzymes known to provide defense against various stresses under different circumstances in plants includes superoxidase dismutase (SOD), peroxidase (POD), catalase (CAT) and those of the ascorbate-glutathione cycle, as well as non-enzymatic antioxidants such as flavones, tocopherols, carotenoids, and ascorbic acid. In ascorbate-glutathione cycle, four known enzymes which take part in various coupled redox reactions are ascorbate peroxidase (APX), monodehydro ascorbate reductase (MDHAR), dehydroascorbate reductase (DHAR), and glutathione reductase (GR). Antioxidant enzymes such as SOD, CAT, APX, POD, GR, and MDAR are known to significantly decrease the levels of superoxide and hydrogen peroxide in plants. In the present study, the concentration of ROS and antioxidant enzymes increases with increase in FA stress. The increased activities of these antioxidant enzymes have a noteworthy role in communicating FA tolerance in plants.

Keeping in view the impact of FA on phytochemical constituents of these plant species, it was found that FA stress caused increase in the quantity of alkaloids, saponins, tannis, flavonoids and glycosides in plant species under study. The variation was noticed in essential phytochemical compounds of these plant species under fly ash stress. In these hostile environmental conditions, plants produce various protective metabolites to lessen the level of stress caused by FA in plants. This may be another reasonable cause for the variation in essential phytochemical compounds of these plant species.