



## **Response of Saffron Plant (*Crocus sativus* L.) against Particulate Pollutants around industrial belt Khrew, Kashmir**

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### Abstract

This study was aimed to know the impact of cement industries dust on various parts of Saffron plant growing at different distances from the cement industrial belt Khrew, Kashmir, India. Sampling was done at different distances ranging from 0.5-2.0 kms from the point source. The chlorophyll, fresh weight of leaves, dry weight of leaves, pH of leaf wash, pH of leaf extracts and leaf size (length) were reduced in dust-exposed plant species as compared to control site Lethapora (13 km away from the cement factories). Survival of plants in the vicinity of industrial areas is being threatened by particulates. Increased concentration of cement dust pollutants causes invisible injuries like progressive decline in photosynthetic ability and closure of leaf stomata and thus affects the growth and productivity of Saffron. Besides the deleterious effects of the dust were expressed by the reduction in size of the leaf, damaged leaf margin and change in colour. Overall study shows that Saffron growing near cement industries were adversely affected physiologically.

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### Introduction

Saffron (*Crocus sativus* L.) is known to be the costliest of all spices due to its extra ordinary properties. Saffron is a non perishable high value, low volume commercial crop of Jammu and Kashmir State. It is a perennial herb mostly known for its beautiful, fascinating fragrance, pleasant flavour, extraordinary healing powers cum medicinal values and aesthetic biodiversity values. Cement industry is one of the most boomed up industry in India. It is second largest cement producer in the world after china. Cement industry is the one of the 17 most polluting industries listed by Central Pollution Control Board. During the last decades, the emission of dust from cement factories has increased alarmingly due to expansion of existing cement plants to meet the requirement of cement

materials for construction work. In comparison with gaseous air pollutants, many of which are readily recognized as being the cause of injury to various types of vegetation (Gupta and Mishra, 1994; Iqbal and Shafiq, 2001), relatively limited studies have been carried out on the effect of cement dust pollution on vegetation especially in Jammu and Kashmir.

Cement dust pollution severely affects the growth and morphology of plants. It might be in the form of visible markings on the foliage such as chlorosis, necrosis, veinal deformities, mottling etc. Ade-Ademilua *et al.*, (2008) reported a significant reduction in shoot length, total leaf area and dry weight of plants affected by cement dust pollution. A significant delay in germination of seeds which was followed by growth retardation in terms of plant height and leaf area, number of leaves, length of petiole, number of flowers and fruits, fresh and dry weight were also seen by Katiyar *et al.*, (2015). Reduction in growth parameters are due to the cumulative effects of the causal factors on the physiological processes necessary for plant growth and its development (Schutzki and Cregg, 2007). Dust deposition reduces diffusive resistance and increases temperature of leaf, making the tree more likely to be susceptible to drought (Farmer 1993). It also causes slight decrease in transpiration rate, stomatal conductance while increasing the leaf temperature.

Photosynthetic pigments mainly- chlorophyll and carotenoid contents, are affected by a variety of stress factors. As these are the dominant photosynthetic pigments in green plants and assessment of their concentrations in foliage provide an estimate of potential photosynthetic capability (Gitelson and Merzlyak, 1996; Carter, 1998). Chlorophyll 'a' is being more severely affected than chlorophyll 'b'. Chlorophyll 'a' is degraded to phaeophytin through replacement of Mg<sup>+2</sup> ions in chlorophyll molecules, while chlorophyll 'b' forms chlorophyllide 'b' through the removal of phytol group of the molecule (Rao and Le Blane, 1966). All the atmospheric pollutants retained by leaves are transformed inside the plant and affect its photosynthesis and respiration. This damage appears in the form of chlorotic and necrotic lesions at leaves level (Landis and Yu, 1995). Analysis of photosynthetic pigments may provide insight into the physiological status of vegetation (Moran *et al.*, 2000).

The present study was undertaken with the objective to assess the impact of cement industries dust on the physiological and morphological attributes of Saffron (*Crocus sativus*) planted in the vicinity of cement industries in Khrew area of Pulwama district in Kashmir.

## **MATERIAL AND METHODS**

**Study area:** Khrew is a town and notified committee area in Pulwama district in the Indian state of Jammu and Kashmir. Khrew is located at 34° 01'08.11"N and 75° 00' 23.95"E. It has average elevation of 1,650 meters. Khrew is 21km away from Srinagar city and is bounded by Wuyan in the west. Ladhu in the south, Shar-e-Shalli in the south East. While as eastern, North eastern and northern boundaries are formed by Satapokhren, Zantrag, Nagandar and Bathen adjoining foot hill villages of Khrew. It is surrounded by

lofty mountains in the north Western, North Eastern and South Eastern directions. The village has a substantial amount of agricultural land covering an area of 1143.01 hectares. The natural vegetation in the study area is generally of herbs and dwarf shrubs. The vegetation on the upper reaches of the northern aspects holds *Pinus wallichiana* as the major cover. Mostly Saffron (*Crocus sativus* L.), Maize (*Zea mays*), Walnut (*Juglans regia* L.), Almonds (*Prunus amygdalus*), Mustard (*Brassica campestris*) and Apricot (*Prunus armeniaca* L.) occupy the major portion of the agricultural land in the vicinity of the cement factories. Industrial activities contributing towards the environmental pollution are Brick Kiln manufacturing, stone crushing and cement manufacturing. Because of improper dust control equipments and at least 40 to 50 stone crushers, 15000 people besides crops are directly affected by the giant cement factories (JK cement a government run enterprise, TCI Max, Cemtac Cements Pvt. Ltd., Itfac Cements Pvt. Ltd., and Dawar (Arco) Cements Pvt. Ltd). The location and distance pattern of different selected sampling sites for the present study were;

**Site-I:** This site was located at a distance of 0.5 km from the JK Cement factory in the southeast direction, with dense human population. The geographical coordinates of the site were 34° 01'48.76"N and 75° 01' 12. 38"E and the altitude of the site was 1730 m above mean sea level. The area is covered with dwarf herbs and grasses with some scattered shrubs.

**Site-II:** This site was located at a distance of 1.0 km from the Cemtac Cement factory in the northeast direction. The geographical coordinates of the site were 34° 01'56.44"N and 75° 02' 05. 22"E and the altitude of the site was 1794 m above mean sea level.

**Site-III:** This site was located at a distance of 1.20 km away from TCI Max, 0.85 km from Dawar (Arco), 0.85km from Itfac, 1.85 km from JK cements and 1.25 km from Cemtac cement factories towards northwest side at an altitude of 1858m AMSL with geographical coordinates 34° 02' 52.22"N and 75° 01' 17.45"E. This site is located in the middle of the industries and receives lot of cement dust released from the above said industries. This site was chosen for studying the cumulative effect of factories. Vehicular emission also added to the pollution level. Various horticultural trees and agricultural crops, of this site are exposed to heavy particulate pollutants.

**Site-IV:** This site was taken as a Reference (Control) site at Lethapora, Pampore at a distance of 13kms far away from the industrial belt Khrew. The area remains under saffron and paddy cultivation with scattered horticultural orchards and it apparently receive least cement dust from the factory or any other kind of source. The geographical coordinates of the site were 33° 58'15.08"N and 74° 58' 57. 87"E and the altitude of the site was 1651 m above mean sea level.

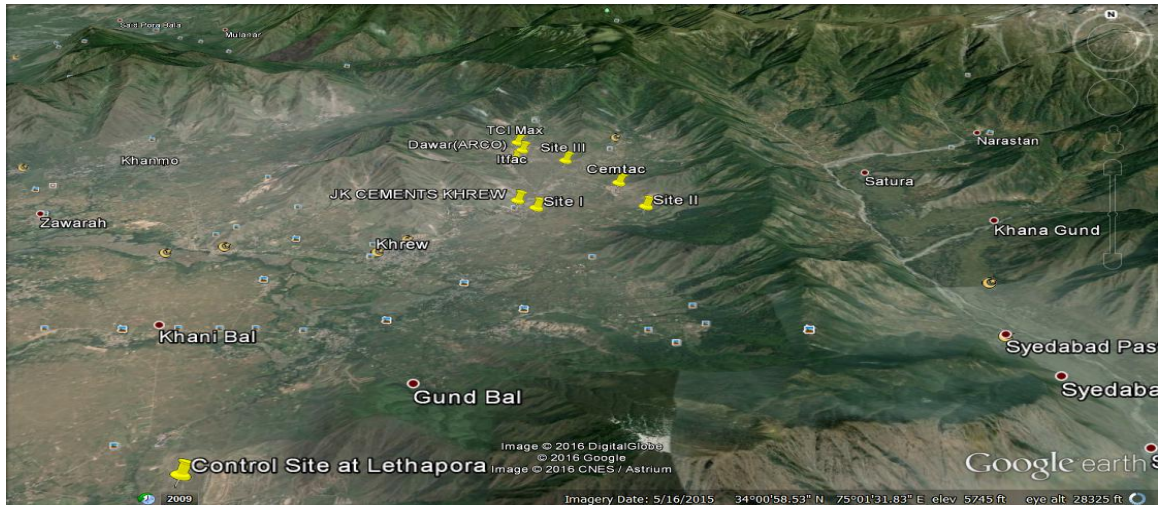


Figure 1 Location and distance pattern of different selected sampling sites

In the present study only Saffron plantations were studied for their response against heavy particulates emitted from cement industries. Collection of samples of vegetative parts of the Saffron plant was performed at each site during 2013 to 2015 on seasonal basis. The samples were analysed for Physico-chemical parameters of chloroplast pigment, pH of leaf wash, pH of leaf extract, Leaf size (cm). Chlorophyll was extracted in 80% acetone and readings were measured at 645, 663, 510 and 480 nm and calculations were made according to Arnon (1949) using absorption coefficient. The dry weight of the leaves was calculated by keeping them in an oven at 80°C for 24 hours, after noting down their leaf area. Then the leaves are weighed and noted. Again the leaves are kept at 80°C for 12 hours and the weight is noted. This process has been repeated till a constant weight has been recorded. The leaf wash pH was determined following Pawar *et al.*, 1988. Leaf extract pH was estimated by method recommended by Singh and Rao, 1983. Leaf size estimation was carried out using planimeter.

## RESULTS AND DISCUSSION:

The impact of cement dust on Chlorophyll pigments and leaf length of Saffron at various study sites around cement industrial area Khrew are given in Table 1. The data reveals that chlorophyll a concentration fluctuated from 0.18 to 0.713 mg/gm, chlorophyll b from 0.03 to 0.272 mg/gm at site III and at control site in Saffron tree. The chlorophyll increases as the age of plant and the distance from industry. The lowest concentration of both (chlorophyll a & b) is found at site III that receives highest dust fall from all industries. Similar results regarding the chloroplast damaged by cement dust on leaf causing reduction in chlorophyll concentration in different plants were reported by Lerman, (1972); Singh and Rao, (1978). The shading effect of such layer could lead to suppression of chlorophyll a synthesis (Peirce, 1910 and Czaja, 1962).

There was significant reduction in both fresh and dry weight of saffron plant. The fresh weight ranged between 50 mg  $\pm$  7 at Site-III, 54 mg  $\pm$  3 at Site-I, 58 mg  $\pm$  6 at Site-II

and 67 mg  $\pm$ 6 at Control Site where as the dry weight ranged between 12mg  $\pm$ 4.582 and 28 mg  $\pm$ 5.56 for each site respectively. A reduction upto 0.50 cm in the average length of the saffron flower was recorded between control and Site-III(most polluted). The change in the floristic characters of the saffron plant was more in the year 2015 than the previous years.

The data reveals that cement dust had a detrimental influence on the plant height. The mean values of all these parameters shows severity was more at Site-III, followed by Site-I and Site-II as compared to that of the reference site. The declined trend as compared to control suggests that *Crocus sativus* being a perennial herb is susceptible to pollution and shows reduced photosynthetic activity and less storage of starch in corm. Such reductions may be due to reduced photosynthesis, through a combination of factors such as reduced interference with the gaseous exchange of foliage due to clogging of stomata, interception in the incident light due to cement encrustation on the leaf surface.

Table 1 Mean Impact of Cement dust deposition on the Chlorophyll pigments, biomass and leaf length of Saffron at various study sites around Cement industrial belt Khrew from (2013-2015).

Parameter	Site-I	Site-II	Site-III	Site-IV
Chlorophyll 'a' mg/g	0.26 $\pm$ 0.146	0.336 $\pm$ 0.179	0.18 $\pm$ 0.100	0.713 $\pm$ 0.362
Chlorophyll 'b' mg/g	0.057 $\pm$ 0.035	0.063 $\pm$ 0.030	0.03 $\pm$ 0.02	0.272 $\pm$ 0.036
Fresh weight of leaves (mg)	54 $\pm$ 3	58 $\pm$ 6	50 $\pm$ 7	67 $\pm$ 6
Dry weight of leaves (mg)	19 $\pm$ 14	24 $\pm$ 17	8 $\pm$ 12	34 $\pm$ 28
pH of leaf wash	9.12 $\pm$ 0.032	8.79 $\pm$ 0.234	9.24 $\pm$ 0.126	7.68 $\pm$ 0.279
pH of leaf extract	7.14 $\pm$ 0.060	7.09 $\pm$ 0.070	7.16 $\pm$ 0.05	6.67 $\pm$ 0.250
Leaf size(cm) (length)	6.26 $\pm$ 0.404	6.53 $\pm$ 0.351	5.6 $\pm$ 0.305	7.00 $\pm$ 0.030

pH of leaf wash and leaf extract are important parameters and used as indicators of air pollution in the area. The pH of leaf wash and pH of leaf extract showed an increase in the values i-e., towards the alkalinity with maximum value in case of site III, followed by site I, site II and minimum value at the farthest site (site IV). With increase in cement dust concentration there was a progressive increase in pH of leaf wash and extract. The rise in pH could be due to the formation of hydroxide of aluminium in the leaf tissue probably increasing pH of the leaf extract. The leaf length of studied saffron showed a significant decline of 1.4 cm (site III) as compared to control site.

The size of saffron plant was fairly smaller, in the close vicinity of the industry as compared to those of the sites away from the source. Cement dust pollution severely affects the growth and morphology of plants. It might be in the form of visible markings on the foliage such as chlorosis, necrosis, veinal deformities, mottling etc. Ade-Ademilua *et al.*, (2008) reported a significant reduction in shoot length, total leaf area and dry weight of plants affected by cement dust pollution. A significant delay in germination of

seeds which was followed by growth retardation in terms of plant height and leaf area, number of leaves, length of petiole, number of flowers and fruits, fresh and dry weight were also seen by Katiyar *et al.*, (2015): Rafiq and Kumawat (2016). In the present study also stunted growth in highly polluted zone and decrease in leaf area could be seen. Overall growth of the test plant was reduced.

## CONCLUSION

The present study has shown that the deposition of cement dust has an effect on vegetation characteristics and natural communities that may alter the competitive balance between plant species. The physio- morphological characters of Saffron plant were studied at different distances from the industry and compared with the control plant. The data obtained from different sites indicate that chloroplast pigment, pH of leaf wash, pH of leaf extract, Leaf size was affected by cement industry pollution. The Saffron plant growing in control site were healthy than the plants growing near the cement factories. As the distance from the industry increases the plant growth also improves. Exposure to particulate deposition may alter plant growth and its physiology without physical damage to the plant. Moreover, accumulation of dust particulates on studied plant leaves could be a major problem in their production. It was proposed that the pigment content of the light harvesting complex is an important aspect related to the tolerance of plants to dust pollution. Chlorophyll content is essential for the photosynthetic activity and reduction in chlorophyll content has been used as an indicator of air pollution since it is fairly sensitive to air pollutants. Very fine particles (<1.0 $\mu\text{m}$ ) present in cement dust closes the stomata thereby interfering with gaseous exchange resulting in detrimental changes in the leaf physiology. In general, the growth and development of plant was found to be affected negatively by cement dust, which may be due to the presence of different toxic pollutants in the cement dust. It clearly indicates that the cement industry pollution affect the photosynthetic activity and chlorophyll content adversely. Therefore, it is suggested that adequate green belt should be developed in and around the industrial area khrew in order to restrict spreading of cement dust.

**Authors' contributions:** Rouf ur Rafiq (Research Scholar), corresponding author, designed the research, generated and interpreted the data and wrote manuscript and Dr D M Kumawat (Professor & Head), helped in designing the research and manuscript writing, supervised the data collection.

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