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The impact of Cement dust pollution on growth and physiological characteristics of plant wealth: A Review

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ABSTRACT

Air pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought and other environmental stresses. The role of air pollutants causing injury to plants either by direct toxic effect or modifying the host physiology, rendering it more susceptible to infection. In severe case of pollution, the injury symptoms were expressed as foliar necrosis or completely disappearance of the plant. The results regarding the deposition of cement pollutants showed that, biomass of fruits/tree, number of branches/tree and number of fruits/branch in polluted locations were significantly lower than those of the control one. It is remarkable that cover and phytomass of Atriplex halimus were increased greatly in response to cement dust pollution, and this was accompanied by a reduction in the mature seeds and leaf-area of the plant. A study indicated that amount of chl a, b and carotenoids in all investigated plants that are far away from cement dust more than that near from the factory. Carbohydrates and protein contents are significantly decreased in non polluted Salsola tetandra and Suaeda vermiculata, whereas these parameters increased significantly parallel to the dust accumulation rate on plants near to the factory. In general, pollution by the cement dust has caused adverse effects on the photosynthetic pigments, the pH of the cell sap, metabolism of soluble amino acids and soluble sugars. The results revealed that fruits of fig plants at polluted sites showed quantitative and qualitative deterioration.

Deposition effect of cement dust on pigmentation was studied in Zygophyllum coccineum, Salsola tetrandra, Cyperus conglomeratus, Limonium axillare.A significant reduction in plant cover, height and number of leaves for Carissa carandas L. was observed. Azadirachta indica (L.) A.Juss. showed no significant changes in plant cover and height with the exception of number of leaves. It was concluded that the cement dust had a significant effect on the plant growth. A. indica was found to be less affected by cement dust pollution, while C. carandas was found to be highly affected. In general, pollution by the cement dust has caused adverse effects on the photosynthetic pigments, the PH of the cell sap and metabolism. In a significant study, the cement dust was artificially sprayed on the plant surface with different levels. All the morphological and biochemical were analyzed. Morphological parameters viz; Root length, Shoot Length, and dry weight were inhibited in high dose of cement deposition when compare control plant. The chlorophyll of control and polluted maize plant were compared and it was found that a maximum reduction of 14.71 per cent of total chlorophyll was recorded at the age of 60 days. Nitrogen and phosphorus was comparatively higher on control maize than polluted one where potassium was reverse. Characteristics of grain of maize had higher value in control maize than polluted maize grains except carbohydrate and calcium.

Deposition effect of cement dust on pigmentation was studied in Azadirachta indica, Pongamia pinnata, Delonix regia, Polyalthia longifolia and Ficus religiosa. Sampling was done about 500 meter distance difference from the cement industry and measurements were taken for all the plant species spectrophotometrically. All the measured pigments were reduced in dust-exposed plant species compared with control site. This is due to deceleration of the biosynthetic processes rather than degradation of pigments. Changes in chlorophyll and carotenoid content were investigated in selected plant species exposed to alkaline dust emitted by the cement industry. The rate of mortality of young branches was high in the area subjected to the cement dust in all the selected plant species whereas Pongamia pinnata and Azadirachta indica are the most sensitive among them. Unless Polyalthia longifolia and Ficus religiosa is noted that amount of chl a, b and carotenoids in all investigated plants that are far away from cement dust more than that near from the factory. In general, pollution by the cement dust has caused adverse effects on the photosynthetic pigments and the pH of the leaf extract.

Key words: *Cement dust pollution, growth and physiology, plants, possible effects*

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Background and importance

One might argue that the seeds of environmental pollution were sown when man lit his first fire, or at least when he smelted his first sulphur ore to recover copper. He was surely familiar with the noxious odour of sulphur dioxide .The history of air pollution, however, is not so much a history of fire in all its technological forms, or even a history of population growth. It has now become a major threat to the survival of plants and crop yield losses in the industrial areas (Fuji, 1973; Gupta and Mishra, 1994). Industries are emitting toxic substances which adversely affect man's food supply by polluting nearby growing plants (Kumar and Thambavani, 2012). The Cement industry plays a vital role in the imbalances of the environment and produces air pollution hazards (Stern, 1976; Thambavani and Saravanakumar 2011). Physiological disorders such as reduced growth are ultimately due to the cumulative effects of the causal factors on the physiological processes necessary for plant growth and its development (Schutzki and Cregg, 2007). Ambient level of air pollution has been shown to affect stomatal conductance, photosynthesis and root morphology of young beech (Taylor and Davies, 1990). One of the most recent studies of these stresses was a dust accumulation, which provokes severe damage in the photosynthetic apparatus (Santosh and Tripathi, 2008).Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem (Clayton and Clayton, 1982).The main atmospheric pollutants are: gaseous-mainly SO_2, NOx, O3, acid rain, heavy metals and dust (Mandre *et al.*, 2000). The heavy metals present in the cement dust may play an important role in disturbing the various metabolic processes of the effected plants (Amal *et al.*,2012).Air pollution has been described as an additional stress since they often respond to atmospheric contamination in the same way as they respond to drought and other environmental stress (Raajasubramanian *et al*.,2011).Increased concentration of pollutants as stated above greatly affect plant growth, phytomass and productivity (Prasad *et al.*, 1991; Larcher, 1995), species composition, tree cover and biodiversity (Ayyad and Fakhry, 1996; Hegazy, 1996). Also, in recent years, many effects of cement dust have been studied on conifers growing in central European forests (Lepedus *et al.*, 2003; Mandre and Ots, 1999).The dust escaping from cement factories is often transported by wind and deposited in areas close and far away from the source as stated above. These include agricultural lands, natural vegetation, towns and villages. Such particulate matter and other pollutants interfere with normal metabolic activities of plants, causing direct injury and impairment of growth and quality and may ultimately leads to decrease in plant yield (Salami and Farounbi, 2002). The cement factories emitting cement dust particles is considered to be one of the main source of environment pollution and produces air pollution hazards (Stern, 1976).These dust particles are causing large scale deforestation, destruction of biota (Panda *et al.,* 1996),effect vegetation (Fakhry and Migahid,2001) and other natural resources. Cement dust is largely made up of cement kiln dust that is a by-product causes changes in soil physio-chemical properties (Asubiojo *et al.*,1991).The effects of such depositions affects the growth and biochemical characteristics of field crops (Prasad *et al.*,1991).According to Farmer (1993) cement industrial regions are confronted with the problems of alkalization due to high deposition of alkaline cement dust and their ash in the pollution complex (Eensaar,1988).The concentrated dust particles in the atmosphere surrounding the plant reduce and probably screen out effect light rays reaching the leaves (Singh and Rao,1981) and the encrustation of cement particles on the leaf surfaces, will effectively seal out light penetration into the leaves coupled with the elevated levels of pH of cement dust strongly affect vegetation growth, by making decrease in rates of photosynthesis, respiration, transpiration and growth rate (Czaja,1961;Liu *et al.*,1997;Panday and Kumar,1996,Satao *et al.*,1993;Sharifi *et al.*,1997). Seed germination and growth are vital for continuation of plant life. Seeds and seedlings are extremely vulnerable to environment stress due to presence of polluting agents in the environment especially during seed hydration period which is very much important for initiating and triggering the investigate sequence of metabolisms essential for germination and growth of seedlings (Anujsaxena, 2003).The information on the effects of settled dust on vegetation is rather meager (Darley,1966) The critical phase of germination in the life cycle of the crop plants is subjected to many environmental stresses. In view of the paucity of information and to have a well documented scientific study on the subject as stated above, present study was carried out to pool together the very recent information on knowing the possible effects of cement dust, coming from the surrounding cement factories, on the growth and physiological characteristics of plants.

Effect of cement dust on seed germination

Different attempts from time to time have been made by the researcher, to find out effect of cement dust on germination. Different concentrations (Control, 5g/Kg, 10g/Kg,15g/Kg, 20g/Kg, 25g/Kg) of cement dust with soil were taken. Seed germination percentage, Seedling length (cm/seedling), Fresh weight (g/seedling), Dry weight (g/seedling), Vigour index, Tolerance Index and percentage of Phytotoxicity, were measured and recorded, in addition to that above said parameters , bio-chemical parameters like chlorophyll, Protein, Amino acid, Total sugar were estimated and recorded on the seventh day after sowing. The lower germination percentage (30), seedling length (5.766 cm/seedling), fresh weight (0.75 g/seedling), dry weight (0.250 g/seedling) and vigour index (172.98) was observed in 25 g/kg cement dust sprayed seedlings as compared to the control which registered. higher germination percentage (100%), seedling length (9.967 cm/seedling), fresh weight (1.90 g /seedling), dry weight (0.666 g/seedling) and vigour index (487), was observed in control plants (Raajasubramanium,*et al.*,2011) Any disturbance in the environment leads to poor seed germination and ultimately the growth and yield of the crop (Dixit *et al.*, 1986). The germination percentage of groundnut seeds was gradually decreased with the increase in the cement dust weight. Moreover 50% reduction of germination percentage was observed at 25 g/kg soil amended concentrations. The better result of germination was observed at control plants. Prasad and Inamdar (1991) reported the gradual decrease of germination was observed when the amount of cement increased. The decrease in germination of seeds with increasing concentrations may be due to toxic effects of metals present in the cement dust which interfere with the normal synthesis of metabolic products, thus directly affecting the cell division and cell elongation (Singh and Srivastava, 2002). The germination percentage growth and their weight were found higher in control when compared to treated seeds. They are not affected at lower concentrations of dust applied upto 5%. The time taken for plumule and radicle emergence was seriously affected at increasing concentrations of the dust (Sundaramoorthy *et al.*, 1997). There was a similar trend of increasing vigour index with increasing dust concentration upto 5% and then gradually declined beyond that level. The length of radicle and plumule is dose dependent which got decreased with increasing concentrations of the cement dust pollution.

The seeds collected from *Atriplex halimus* individuals grown in vicinity of the cement factory (affected plants) differed in maturation than those collected from individuals grown in the farthest site (unaffected plants). The germination experiment for affected and unaffected seeds showed a significant difference in the germination percentages especially under stress condition (100 mM mannitol). The germination percentages of the affected seeds were generally higher than those of the unaffected ones (Fakery and Migahid, 2001). It is also remarkable that the germination percentages of the seeds affected by cement dust were reduced by one third when exposed to water stress (under mannitol treatment), while the germination percentages of the unaffected ones were reduced by half under stress using mannitol. The root and shoot lengths (cm) of the seedlings from the seeds affected by cement dust were increased significantly by about 34.8 % and 26.8 %, respectively, as compared with the length of seedlings from the unaffected control treatment. The present study also reveals that treatment with mannitol (water stress) resulted in a considerable decrease in both root and shoot lengths of the emerged seedlings from both the affected and unaffected seeds. The root and shoot lengths of the affected seedlings, were found, to be reduced by 39.6 % and 29.9 %, respectively, when exposed to water stress by mannitol. The root and shoot lengths of the unaffected seedlings were also found to be reduced under mannitol treatment by about 72.4 % and 31.5 %, respectively. The seedlings from both affected and unaffected seeds showed a general trend of reducing root/shoot ratio when exposed to stress by mannitol treatment, while the reduction was lowest in case of the unaffected one.

Effect of cement dust on plant growth characteristics

Cement dust had a significant effect on the growth of some plant species compared with non cement dusted plants. Toxic compounds such as fluoride, magnesium, lead, zinc, copper, beryllium, sulfuric acid and hydrochloric acid were found to be emitted by cement manufacturing plants (Andrej, 1987). Reduction in plant height, cover and number of leaves of *C. carandas* showed that the losses are generally attributed to the cement dust which contained toxic metals. The results obtained are in close conformity with those reported by Stratmann and Van Haut (1966), who dusted plants with dust ranging from 1 to 48 g/m2 day -1 and concluded that dust falling on the soil caused a shift in pH to the alkaline side, which was unfavorable to oats but favorable to pasture grass. Decreased plant height of *Dalbergia regia* might be due to the decrease in phytomass, net primary production and chlorophyll content in response to the cement dusts, confirming the findings of Prasad and Inamdar (1990) in *Vigna mungo* (Black gram). The cement dust kiln showed a reduction in chlorophyll content, protein, starch, yield and phytomass in ground nuts (Prasad and Inamdar, 1990). A significant reduction in leaf number for *C. carandas, A. indica and D. regia* agrees with the findings of Anda (1986). Plant response varies between species of a given genus and between varieties within a given species. Plants do not necessarily show similar susceptibility to different pollutants. Major variations in response to different species to air pollutants have been documented by Jacobson and Hill (1970). Studies of biochemical changes and pollution effects on the plant metabolism, i.e., reduction in chlorophyll and completely clogged stomates (Ahmed and Qadri, 1975) reveals that these parameters are important in regulating the productivity and also the number of flowers and seeds produced. *C. carandas* was found to be significantly affected in all the growth parameters. It is concluded that the presence of toxic pollutants in cement dust might be responsible for the reduction in plant growth. Traces of toxic metals such as chromium and copper are common in some varieties of portland cement and are harmful to human beings and other living systems (Omar and Jasim, 1990). The heavy metals present in the cement dust can play an important role in disturbing the various metabolic processes. The growth metabolic processes and yield of winter barley were found to be affected by the Duna cement and lime works (Borka, 1986). Greszta *et al.*, (1988) in an experiment of six kinds of dust which contained heavy metals introduced under the stand canopy. The dust was collected from zinc, cadmium, aluminum, iron plants, electric power station and the cement plant. The dust was introduced in concentrations of 100, 500, 1000, 2000 and 5000 t Km-2. The experiment proved that the cement dust brought about changes in the ecosystem. A link between the forest ecosystem under the influence of heavy metals in dust and the effect of these changes on the growth of pine stands was also obtained. A significant reduction in plant cover of *C. carandas* compared with other species suggests that C. carandas is more sensitive to cement dust than the other species studied. Shafiq and Iqbal (1987) found a reduction in the number of species around the heavily polluted cement industrial units in Karachi. Darley *et al.* (1966) demonstrated that dust deposited on bean leaves in the presence of free moisture interfered with the rate of carbon dioxide exchange, but no measurements of starch were made. Studies of the effects of cement-kiln dust deposited on the soils also raised questions. Some investigators reported no harmful effects of cement at levels from 1.5 to 7.5 g/m2/day, while others reported that concentrations from 1.0 to 48 g/m2/day caused shifts in the soil alkalinitiy which may be favorable to one crop but harmful to others (Lerman and Darley, 1975). A quantitative estimation along with dust analysis confirms the ill effects of cement dust on the plant growth. The pH of dust sample was basic in nature which was 9.5 and can be correlated with the findings of the Lerman and Darley (1975). In their experiment, they also found a similar range of cement dust pH (9.5-11.5). It is important to know the identity of various pollutants and their amounts to evaluate their ill effects and toxic stresses (Tinsley, 1979). The changes in the accumulation of mineral plant nutrients as a result of cement dust were also determined by Lal and Ambasht (1981). It is also suggested that complete analysis of cement dust containing all the toxic pollutants should be carried out in detail. It is hoped that, eventually, with such types of study, it would be possible to recommend plants for use as screens or green belts in industrial areas and adverse urban locations in order to mitigate dust and improve air quality (Yunas *et al.*, 1985).

In general various plant species such as *C. carandas*, *A. indica* and *D. regia* showed a decrease in plant growth due to cement dust treatment. *A. indica* showed a significant ($p<0.001$) reduction in number of leaves on the fourth week of observation. The plant height was significantly ($p<0.001$) decreased in A. indica but plant cover remained unchanged. A highly significant ($p<0.001$) reduction in plant height, cover and number of leaves was found for *C. carandas* on the second, third and fourth weeks of observation, respectively. There was no significant change in plant cover for *D. regia*. However, it showed a significant reduction in number of leaves ($p<0.01$) and plant height ($p<0.05$) on the fourth and fifth weeks observation. The dust collected from the vicinity of the National Cement Factory showed a high percentage of maximum water holding capacity (65.72%) and fine texture particles. The chemical composition of the soil was alkaline in nature having pH 9.5 with a better percentage of calcium carbonate (22%) and alkaline carbonate (2.45 meq/1). The chloride and conductivity were 8.6 meq/1 and 506 µs/cm, respectively. Cement dust had a significant effect on the growth of some plant species compared with non cement dusted plants. Toxic compounds such as fluoride, magnesium, lead, zinc, copper, beryllium, sulfuric acid and hydrochloric acid were found to be emitted by cement manufacturing plants (Andrej, 1987). Reduction in plant height, cover and number of leaves of *C. carandas* showed that the losses are generally attributed to the cement dust which contained toxic metals. The results are in close conformity with those reported by Stratmann and Van Haut (1966), who dusted plants with dust ranging from 1 to 48 g/m2 day -1 and concluded that dust falling on the soil caused a shift in pH to the alkaline side, which was unfavorable to oats but favorable to pasture grass. Decreased plant height of *D. regia* might be due to the decrease in phytomass, net primary production and chlorophyll content in response to the cement dusts, confirming the findings of Prasad and Inamdar (1990) in *Vigna mungo* (Black gram). The cement dust kiln showed a reduction in chlorophyll content, protein, starch, yield and phytomass in ground nuts (*Arachis hypogaea* L.) (Prasad and Inamdar, 1990). A significant reduction in leaf number for *C. carandas, A. indica and D. regia* agrees with the findings of Anda (1986). Plant response varies between species of a given genus and between varieties within a given species. Plants do not necessarily show similar susceptibility to different pollutants. Major variations in response to different species to air pollutants have been documented by Jacobson and Hill (1970). Studies of biochemical changes and pollution effects on the plant metabolism, i.e., reduction in chlorophyll and completely clogged stomates (Ahmed and Qadir, 1975) reveals that these parameters are important in regulating the productivity and also the number of flowers and seeds produced. *C. carandas* was found to be significantly affected in all the growth parameters. It is concluded that the presence of toxic pollutants in cement dust might be responsible for the reduction in plant growth. Traces of toxic metals such as chromium and copper are common in some varieties of portland cement and are harmful to human beings and other living systems (Omar and Jasim, 1990). The heavy metals present in the cement dust can play an important role in disturbing the various metabolic processes. 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Shafiq and Iqbal (1987) found a reduction in the number of species around the heavily polluted cement industrial units in Karachi. Darley *et al.*, (1966) demonstrated that dust deposited on bean leaves in the presence of free moisture interfered with the rate of carbon dioxide exchange, but no measurements of starch were made. Studies of the effects of cement-kiln dust deposited on the soils also raised questions. Some investigators reported no harmful effects of cement at levels from 1.5 to 7.5 g/m2/day, while others reported that concentrations from 1.0 to 48 g/m2/day caused shifts in the soil alkalinitiy which may be favorable to one crop but harmful to others (Lerman and Darley, 1975). A quantitative estimation along with dust analysis confirms the ill effects of cement dust on the plant growth. The pH of our dust sample was basic in nature which was 9.5 and can be correlated with the findings of the Lerman and Darley (1975). In their experiment, they also found a similar range of cement dust pH (9.5-11.5). It is important to know the identity of various pollutants and their amounts to evaluate their ill effects and toxic stresses (Tinsley, 1979). The changes in the accumulation of mineral plant nutrients as a result of cement dust were also determined by Lal and Ambasht (1981). It is also suggested that complete analysis of cement dust containing all the toxic pollutants should be carried out in detail. It is hoped that, eventually, with such types of study, it would be possible to recommend plants for use as screens or green belts in industrial areas and adverse urban locations in order to mitigate dust and improve air quality (Yunas *et al.*, 1985). On the basis of this study, it could be concluded that growth of plants was found to be affected by cement dust, which might be due to the presence of different toxic pollutants in cement dust. The phonological behavior of *C. carandas* was found to be highly affected followed by *A. indica* and *D. regia*, respectively. It is clear that the cement dust pollution is an operative ecological factor causing deterioration in the quality of our environment. It is suggested that *D. regia* should be planted around the cement industrial units due to its resistant to cement dust toxicity.

Effect of cement dust on leaf physiology and photosynthesis

Cement dust may change leaf physiology leading to reduced productivity (Nanos and llias, 2000). Photosynthetic pigments (chl a, chl b, carotenoids) were declined with cement dust accumulation causing an increase in chl a/b ratio in location 1 (3.5) while decrease in the others locations. chl (a + b) also decreased with increased cement dust about 52% and 27% in locations 1 and 2 respectively and about 8% in location 3.This leads to a decrease in photosynthetic rate and quantum yield and could be explained on the bases of quantitative as well as qualitative changes in the incident light available for photosynthesis in cement dusted leaves (Bohne, 1963).These results indicate the percentage of chl a/b ratio increased in more pollutant location 1 caused by great decrease in chl b about 60% compared with its value at control, while a marked decrease in chl a/b ratio was observed in the other locations 2 and 3. The changes in chlorophylls a and b are possibly due to shading and/or photosystem damage (Nanos and llias, 2007).The higher content of chlorophyll (0.281), protein (0.751), amino acid (2.758), total sugar (2.437) and the lower content chlorophyll (0.101), protein (0.305), amino acid (0.603) and total sugar (1.078) was observed in control and 25g cement dust treatment. They are expressed in mg g-1 fr. wt. basis. Studies of pollution on biochemical changes the plant metabolism i.e., reduction in chlorophyll and clogged stomata (Ahmed and Qardir, 1975) reveals that these parameters are important in regulating the productivity and also the number of flowers and seeds produced. In this experiment, the biochemical studies such as chlorophyll, carotenoid, protein, amino acid and total sugars were analyzed. All the biochemicals are gradually decreased with the increase in cement. The higher chlorophyll, carotenoid, protein, amino acid and sugars were observed in control plants and the lower values of these parameters were observed in higher concentrations of cement dust sprayed plants. Moreover 50% reduction of biochemical contents was observed at 25 g soil mixing cement dust concentrations when compared with control. Similarly, these parameters were increased with the increase in the age of the plant. The shoot contains higher protein, amino acid and sugars than the root in all the concentrations. The chlorophyll 'a', chlorophyll 'b', total sugars, protein, starch, lipids and amino acids are gradually decreased in dust polluted plants than in control plants (Uma and Ramana Rao, 1996). The amounts of chlorophyll 'a', chlorophyll 'b', total chlorophyll and carotenoid contents of cement dust treated samples were always lower than that of control plants. A maximum reduction of 1.80% of total chlorophyll was recorded in 10% treatment at the age of 45 days. Decrease in chlorophyll content might be due to chloroplast damage by incorporation of cement kiln dust into leaf tissues (Singh and Srivastava, 2002). Similar results were observed in maize crop (Pandey *et al.*, 1999), water (Pandey and Simba, 1990) and gram leaves (Pandey and Simba, 1989). Chlorophyll 'a', chlorophyll 'b' and total chlorophyll showed a similar trend of reduction. They are sample of evidence concerning the detrimental effects of gaseous pollutants, which are acidic in nature on chlorophyll molecules (Treshow, 1984). The gaseous pollutants such as SO2 at higher concentrations, degrades chlorophyll to a photosynthetically inactive phaeophytin and Mg++. A similar conversion of chlorophyll to phaeophytin can occur with acids where Mg++ in the chlorophyll molecule is replaced by two atoms of hydrogen, thereby changing the light spectrum characteristics of chlorophylls. A considerable loss in total chlorophyll in the leaves of plants exposed in severe air pollution supports the argument that the chloroplast is the primary site of attack by air pollutants which make their entrance into the tissues through the stomata and cause partial denaturation of the chloroplast and decreases pigment content in the cells of polluted leaves.The study shows that the protein content were found to be decreased in both germination studies and pot culture experiments. Reduction in protein content might be due to the enhanced rate of protein denaturation (Tripathi and Gautham, 2007; Prasad and Inamdar, 1990a). The enhanced protein denaturation and breakdown of existing protein to amino acid is the main cause of reduction in protein content (Constantinidou and Kozlowski, 1979). The reduction in protein content might be due the results of decreased photosynthesis on the other hand, decrease in protein content could be attributed either to break down of existing protein or due to reduced de novo synthesis (Singh and Jothi, 1999). Soluble sugar is an important constituent and source of energy for all living organisms. Plants manufacture this organic substance during photosynthesis and breakdown during respiration. The concentration of soluble sugar is indicative of the physiological activity of a plant and it determines the sensitivity of plants to air pollution. The sugar content was found to be reduced with the increase in the of amount cement dust applied. Reduction in soluble sugar content in polluted stations can be attributed to increased respiration and decreased CO2 fixation because of chlorophyll deterioration (Tripathi and Gautam, 2007).

Dust accumulation altered the chlorophyll and carotenoid contents in all plants in the polluted location (near the factory) compared with plants far from the factory in control site. Greater decrease in chlorophyll a and b contents were clearly observed in *Salsola tetandra* and *Limonium axillare* (For chl a about -36% and -45%, respectively). A similar pattern of decrease was occurred in *Zygophyllum coccineum* and *Suaeda vermiculata* but to lower extent (about -15 and -9%, respectively).

On the other hand, Chlorophyll a, b and chl a/b ratio were significantly increased in *Cyperus conglomeratus* together with increasing dust accumulation in plant leaves near to the factory(Amal *et al.*,2012). Chlorophyll a/b ratio for the other four studied plants were decreased in the polluted plant's leaves near the factory and compared with plants far from the dust. Also, the change in the carotenoids content showed the same pattern. There was a significant reduction in carotenoids content particularly for *Suaeda vermiculata Salsola tetrandra*, and *Limonium axillare* to less than 10, 33, and 46 %, respectively. For the leaves of *Zygophyllum coccineum* and *Cyperus conglomeratus* a substantial increase in the carotenoids content in response to dust accumulation near the factory occurred. Thus 42 % and 23% of the increase in the content compared to the control plants, respectively. The chlorophyll/carotenoid ratio decreased in *Zygophyllum coccineum* and *Salsola tetandra* plants near to the factory indicating the increase in carotenoid content with respect to non polluted plants.

Total carbohydrates content were markedly decreased with increasing dust pollution near the factory for the leaves of *Salsola tetandra* and *Suaede vermiculata* to less than 16 and 29%, respectively compared with non polluted plants, whereas, increased significantly near to the factory and parallel to dust accumulation in *Zygophilum coccineum*, *Cyperus conglomerotus* and *Limonium axillare*. Considerable increases in the soluble sugars that were detected in all plants except *Suaede vermiculata*. Similarly, total protein increment was recorded, especially the soluble protein content in all polluted plants near to the factory except *Salsola tetandra*. Soluble/total protein and soluble/ total carbohydrates ratios were increased in all polluted plants compared with the non polluted plants. The accumulated elements in leaves of plants differed from one species to another in response to cement dust pollution. All the elements (Fe, Mn, Mg and N) in the leaves of *Z. coccineum* and *S. tetandra* were significantly lower in the polluted plants than in the control plants, whereas, their contents in the leaves of *C.*

conglomerotus and *S. vermiculata* were significantly higher .In leaves of *L.* axillare, the level of element's accumulation (Mg and N) was significantly lower in polluted plant than in control plant but significantly it was higher for Mn and Fe.

The maximum total chlorophyll values of 2.10 and 1.77 mg chlorophyll/g fresh leaf were found in 60 days old control and dusted maize plants respectively. The maximum chlorophyll a value of 1.66 (control) and 1.39 (dusted) mg chlorophyll/g fresh leaf were found at the age of 60 days respectively. The highest chlorophyll b values of 0.44 and 0.38 mg chlorophyll/g fresh leaf were found at the age of 60 days on control and dusted maize plants respectively. When compared with the control, a maximum reduction of 14.71 per cent of total chlorophyll was recorded in 60 days old dusted plants (Kumar and Pandey,2011) The chloroplast damage by incorporation of cement solution into leaf tissues caused reduction in the chlorophyll concentration of dusted leaves was also reported by Czaja, (1962); Lerman, (1972); Singh and Rao, (1978). The shading effect of such layer (Peirce, 1910 and Bohne, 1963) could lead to suppression of chlorophyll a synthesis.

Dust accumulation altered the chlorophyll and carotenoid contents in all plants in the polluted location (near the factory) compared with plants far from the factory in control site. Greater decrease in chlorophyll a and b contents was clearly observed in *Pongamia pinnata* (L) and *Azadirachta indica (*L) (For chl a about 62.62% and 60.83% and 70.75% and 73.13% respectively). A similar pattern of decrease was occurred in *Polyalthia longifolia*(L) and *Ficus religiosa*(L) but to lower extent (about 51.43% for chl a and 59.12% for chl b, respectively).On the other hand, Chlorophyll a, b, total chlorophyll and chl a/b ratio were significantly increased in *Ficus religiosa* (L) together with increasing dust accumulation in plant leaves near to the factory. Chlorophyll a/b ratio for the other four studied plants were decreased in the polluted plant's leaves near the factory and compared with plants far from the dust. Also, the change in the carotenoids content showed the same pattern. There was a significant reduction in carotenoids content in all the selected species compared to the control plant species. The chlorophyll/carotenoid ratio decreased maximum in *Pongamia pinnata, Delonix regia and Azadirachta indica* plants near to the factory indicating the increase in carotenoid content with respect to non polluted plants. The present results showed that the two locations (polluted and control) received different amounts of cement dust as indicated by the measurements of pH for the leaves' washing solution. The pH ranged in polluted plant from 8.0 - 9.5 and in control site from 6.8 - 7.2, whereas, the accumulation of the cement dust increased the alkalinity of the cell sap for the plant leaves near the factory (9-9.3) (Kumar and

Thambavani,2012). Cement dust had a significant effect on the growth of some plant species compared with non cement dusted plants. Toxic compounds such as fluoride, magnesium, lead, zinc, copper, beryllium, sulfuric acid and hydrochloric acid were found to be produced by cement manufacturing plants (Andrzej, 1987; Thambavani and Saravanakumar, 2011). A quantitative estimation along with dust analysis confirms the ill effects of the cement dust on the plant growth. The pH of dust sample was alkaline in nature; its pH was 9.5 and could be correlated with the findings of Lerman and Darley (1975). They also found a similar range (9.5-11.5) of cement dust pH. The changes in the accumulation of mineral plant nutrients as a result of cement dust were also determined and showed a consistent result with those obtained by Lal and Ambash (1981). It is also suggested that the complete analysis of the cement dust contains all the toxic pollutants should be carried out in detail. The heavy metals present in the cement dust may play an important role in disturbing the various metabolic processes. As it would be possible to recommend these plants in the current study for use as screen or green belts in the industrial localities and adverse urban localities in order to mitigate dust and improve air quality (Yunas *et al*., 1985). Our results are consistent with the results of George and Ilias (2007) who reported that the traces of toxic metals such as chromium and copper are common in some varieties of Portland cement and are harmful to human being and other living systems. Our data indicates that the exposure of plants to dust altered several physiological and biochemical parameters that were triggered. The most apparent effect of stress induced by dust, described in numerous species, is leaf damage (Naidoo and Chirkoot, 2004)..Various studies have shown that the main detrimental effect of dust at the sub cellular level is photo system damage (Nanos and Ilias, 2007; Santosh and Tripathi, 2008). Moreover, the presented results clearly showed that dust altered several biochemical aspects, such as photosynthetic pigment in leaves. A significant percentage increase in chl a/b ratio was observed only in *Polyalthia longifolia* which was mainly caused by an increase in chlorophyll *a* content associated with decrease in chlorophyll *b* content. On the other hand, a marked percentage decrease in chl a/b ratio was observed in the other four studied plants. The changes in chlorophyll a and b are possibly due to shading and/or photo system damage due to dust accumulation between the petioles or other effects on stomata. Dust from a cement factory seems to cause substantial changes to leaf physiology, possibly leading to reduced plant productivity. Our results are consistent with Nanos and Ilias, (2007) who reported that cement dust decreased the leaf total chlorophyll content and chlorophyll a/chlorophyll b ratio. As a result, photosynthetic rate and quantum yield decreased.

Effect of cement dust on Essential elements

Essential elements, such as Fe, Mg, Na, Ca, and K play an important role in plant nutrition and can affect crop yields when not present in appropriate concentration levels (Pestaina *et al*., 2004). The present study shows that, cement dust affected on nutrient elements accumulation in edible mature fruits . Nutrient elements, such as Fe, Mg and Ca were more accumulated in mature fruits in response to cement dust stress, which agrees with Ade-Ademilua (2008) who reported that, cement pollution increased the concentration of Fe and Mg in leaves and stems of *Celosia argentea.*

Alkaline dust deposited on trees and alkalized growth substrate caused serious deviation in the mineral composition of young conifers. An increase in the average Ca, K, Mg and Fe concentrations was found in the investigated trees. Compared with the trees growing in the control area, the concentrations of these elements were about 155, 82 and 38% higher, respectively. The highest concentrations of Ca and K were observed in the needles of polluted trees. As a consequence of cement dust exposure the contents of several elements (P, Mg, Fe, K) were higher than in the control trees in the above-ground organs, while in the roots they were close to (K, Mg) or significantly lower (Fe, P) than in the control trees (except in *Picea mariana*) . The average concentrations of P and Fe in the needles of polluted trees had increased by 89 and 423%, respectively, but in the roots their concentrations were less, being 55 and 47% of the control. The changes in the chemical composition of trees under stress showed a high variability between species. For example, in *Picea abies* an essential decrease in N concentration was found, which was as the average of different organs by 30-50% lower than that in the control trees. At the same time in *Pinus sylvestris* the differences in the content of N in the needles from the control did not exceed 12% and no essential changes were observed in the roots, stems and shoots. A drastic decrease in the content of Mn was found in all species and in both organs of the young conifers (Mandre et al.,2000). An essential Mn deficiency was established in the polluted trees. The Mn concentration in the roots of *Pseudotsuga merlziesii* was only 25.0 mg g-' d.w. and in the shoot needles 8.8-22.3 pg g-' d.w.

Conclusion

Pooling together the very recent information on the impact of cement pollution on the growth characteristics of plants, the following general conclusions can be made from the literature search and experimental investigations carried out so for in this study:

1. The exposure to dust pollution stress provoked important reductions in photosynthesis in most studied plants except *Cyperus conglomeratus*. This study indicates that exposure to particulate deposition may alter plant growth without physical damage to the plant. Moreover, accumulation of dust particulates on studied halophytic leaves could be a major problem in their production. We propose that the pigments content of the light harvesting complex is an important aspect related to the tolerance of plants to dust pollution.
2. The growth of plants was found to be affected by cement dust, which might be due to the presence of different toxic pollutants in cement dust. The phenological behavior of *C. carandas* was found to be highly affected followed by *A. indica* and *D. regia,* respectively. It is clear that the cement dust pollution is an operative ecological factor causing deterioration in the quality of our environment It is suggested that *D. regia*

   should be planted around the cement industrial units due to its resistant to cement dust toxicity.
3. It also reveals that cement factories in arid regions influence both vegetation diversity and the responses of individual species. The studied plant community exhibited an obvious decrease in vegetation diversity in response to cement pollution exerted by the cement factory at El-Hammam area. Annual species were found to be more sensitive to cement kiln dust pollution, and they failed to persist in sites subjected to high levels of disturbance. The lower diversity is always accompanied by high dominance that could be attributed to the high contribution of Atriplex halimus in the abundance distribution of perennial species in the study area. The remarkable increase in *Atriplex halimus* cover in response to cement-kiln dust pollution is accompanied by reduction in the plant seeds maturation, but the few provided seeds by the affected plant individuals exhibited hardening against water stress, and seemed to be more fertile and attain higher germination percentages than the unaffected ones. Root/shoot ratio of the affected seedlings was slightly increased due to the increase in root length. Further studies may be conducted in future to provide evidences of *Atriplex halimus* responses to cement-kiln dust pollution, and

to insure natural recovery after degradation in order to maintain and preserve biological diversity.

4. The growth of fig plants were found to be affected by cement dust which might be due to the presence of different toxic pollutants in cement dust especially thallium which is significance for animals and human health. Cement dust seems to cause substantial changes to leaf physiology by destroying the photosynthetic pigments and interrupted the metabolism of carbohydrates, amino acids and proteins, also affected on the uptake and accumulation of nutrient elements from the soil which finally affected on the economic yield of fig trees (edible parts) quantitatively and qualitatively .
5. It was also concluded that maize cultivation could suffer both in size and in term of quality in cement dust polluted areas.
6. The comparison of five plant species of different dust susceptibility permitted determining that the tolerance or sensitivity to dust pollution was clearly manifested throughout the photosynthetic activity. The exposure to dust pollution stress provoked important reductions in photosynthesis in most studied plants except *Polyalthia longifolia*. This study indicates that exposure to particulate deposition may alter plant growth 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 pigments content of the light harvesting complex is an important aspect related to the tolerance of plants to dust pollution.

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References

Ade-Ademilua,O.E and D.A. Obalola (2008). The effect of cement dust pollution on *Celosia argentea* (Lagos Spinach) plant. *Journal of Environmental Science and Technology*. 1 (2) 47-55.

Ahmed, Z and S.A. Qadir (1975). The effects of air pollution on stomatal clogging, carbohydrate and chlorophyll contents in certain roadside plants. *Pakistan Journal of Botany* ,7: 81-84.

Amal,M., A.Rahman and M M. Ibrahim (2012).Effect of cement deposition on physiological behaviours of some halophytes in the salt marshes of Red sea. *Egypt.Acad.J.bilog.Sci*.,3(1):1-11.

Anda, A (1986). Effect of cement kiln dust on the radiation and water balance and yields of winter wheat. *Acta Agronomica Hungarica.* 36(3-4): 267-275.

Andrzej, J. (1987). Bees and their products as indicators of environment pollution. *Med Water*. 43(6): 352–356.

Asubiojo, O.I., Aina P.O. and A.F. Oluwole (1991). Effect of cement production on the elemental composition of soil in the neighbouhood of tow cement factories. *Water Air Soil pollution* ,57-58:819-828.

Ayyad, M and A. Fakhry (1996). Plant biodiversity in the western Mediterranean desert of Egypt. *Verhandlungen der Gesellschaft fur Okologie*, 25: 56-76.

Bohne,H (1963). Schadlichkeit von Staub aus Zementwerken fur waldbestande, *Allg. Forstz*. 18 :107-111.

Borka, G (1986). Effects of cement dust on the growth development, major metabolic processes and yield of winter barley in situ and under controlled conditions. *Acta Agron Hungary* ,35(1/2): 45-52.

Clayton, G.D.and F.E. Clayton (1982). Pattys industrial hygiene and technology, *Wiley Interscience*, New York.

Constantinidoa, H.A. and T.T. Kozlowski (1979). Effect of SO2 and O3 on Ulmus American seedlings. 1. Visible injury and growth, 2. Carbohydrate, protein and lipids.*Can. J. Bot.*, 57: 170-184.

Greszta, J., Braniewsk S., Chrzanowski E., Noseki A., Chlodnx J and R.J Zwozinkski (1988). Influence of dusts from chosen industrial plants on particular links of Ecosystem of Niepobomiece Forest. *Ekology Pol.* 35(2): 29-32.

Czaja,A.T (1961). Dic Wirkung von vcrstaubtcm Kalk und Zclncnt auf Pflanzcn. *Qual. Plant. Matcr. Vcg.* 8: 184-212.

Czaja, A.T. (1962). Uber das problem der zementstaubwirkungen auf Pflanzen Von Zementofenstaub auf Pflanzen. *Angew. Bot.* 40 : 106- 120.

Darley,E.F. (1966).Studies on the effect of cement dust on vegetation.*Journal of the Air Pollution Control Association*,16 (3):145-150.

Darley,G.D.E.F., Drugger, W.M., Mudd, J.B., Ordin, L., Taylor, O.C and E.R. Stephe (1966). Plant damage by pollution derived from auto mobiles. *Arch Environment Health,* 6: 700-761.

Dixit, A., Lalman,M and S.K. Srivastava (1986). Effect of cardboard effluent on seed germination and early growth of rice (*Oryza sativa* L.) seeds. *Seed Res.*, 14: 66-71.

Eensaar, A (1988). Ohu saastumisc problccnlid [Problems from air pollution]. In: Ecsti Gcograafia *Scltsi aastaraamat*. Tallinn, p. 26-37 (in Estonian).

Fakhry,A.M and M.M.Migahid (2011).Effect of cement-kilin dust pollution on the vegetation in the western Mediterrnean Deserts of Egypt.*World Academy of Science,Engineering and Technology*,57:28-34

Farmer, A.M (1993): Effect of dust on vegetation – A Review. *Environmental pollution,* 79: 63-75.

Fuji, S (1973). The current state of plant damage by air pollution in Okayama Perfecture. *Shokbutsu Boeki*, 27: 249-252.

George, D. N. and F. I. Ilias. (2007). Effects of inert dust on olive (*Olea europaea* L.) leaf physiological parameters. *Environmental Science and Pollution Research*. 14(3):212-214.

Gupta, A.K and R.M.Mishra (1994). Effect of lime kilns air pollution on some plant species. *Pollution Research,* 13(1): 1-9.

Hegazy, A. K (1996). Effects of cement-kiln dust pollution on the vegetation and seed-bank species diversity in the Eastern desert of Egypt. *Environmental Conservation*, 23: 249-258.

Jacobson, J.S and A.C. Hill (1970). Recognition *Air Pollution Control Association Pittsburgh* of Air Pollution Injury to Vegetations: A Pictorial Atlas. Pennsylvania.

Kumari,A and D.D.Pandey (2011).Response of maize to cement dust pollution.*World Journal of Science and Technology*,1 (5):150-155.

Kumar,S and Thambavani. R.S.D (2012)**.**Effect of Cement Dust Deposition on Physiological Behaviors of Some Selected Plant Species. *International Journal of Scientific and Technology Research,* 1(9):98-105

Lal, B. and R.S.Ambasht (1981). Impact of cement on the mineral and energy concentration of Psidium guayava. *Environmental Pollution (Series A*), 29: 241-249.

Larcher, W (1995). Physiological plant ecology. *Springer-Verlag*, Berlin, Germany.

Lerman, S (1972). *Cement kiln dust and the bean plant (Phaseolus vulgaris) in depth investigation into plant morphology, physiology and pathology*. Ph.D. Thesis, University of California, Riverside

Lerman, S.L and Darley E.F (1975). Particulates, In. Responses of Plants to Air Pollution. pp. 141. New York: Academic Press.

Liu ,J.L.,Shang,L.D.U.M.,Chen,S.Y., Xu,HB and M.Y.Xie (1997). The effecty of cement dust pollution on rice, rape and soil. *Journal of Plant Resource Environ*,6:42-47.

Lepedus, H., Cesar, V and M.Suver (2003). The annual changes or chloroplast pigments content in current- and previous year needles or Norway spruce (*Picea abies* L. Karst.) exposed to cement dust pollution. *Acta Botanica Croatica*, 62: 27–35.

Mandre, M and K. Ots (1999). Growth and biomass partitioning of 6-year-old spruces under alkaline dust impact. *Water Air Soil Pollut*, 114: 13–25.

Mandre,M J.Kloseiko and K. Ots (2000).The effect of cement dust on the growth, content of nutrients and carbohydrates in various in various organs of five conifer species.*Baltic Forestry*,6 (2) 16-23.

Naidoo, G. and D. Chirkoot. (2004). The effects of coal dust on photosynthetic performance of the mangrove, *Avicennia marina* in Richards Bay, South Africa. *Environmental Pollution*. 127 (3) 359-366.

Nanos,G.D and I.F. Ilias (2007). Effect of inert dust on olive (*Olea europaea* L.) leaf physiological parameters, *Environ. Sci. Pollut. Res*., 14 (3) (2007) 212-214.

Omar, J.M and J.Jasim (1990). Some observations on the use of electro thermal atomic absorption spectorpotometry for the determination of chromium and copper in portland cement. *Microchemistry Journal*, 41(3): 348-355.

Panda, A.K.S., Murlidhar J and B.N.Shahoo (1996). Seasonal water quality assessment of jajang Iron and mining area .*Jr. of Industrial pollution control*. 12 (1):9-14.

Pandey,D.D and S.Kumar (1996). Impact of cement dust pollution on biomass, chlorophull, nutrients and grain characteristics of wheat. *Environ Ecol*,14:872-872.

Pandey, D.D., A.K. Nirala and R.R. Gaulam (1999). Impact of stone crusher dust pollution on maize crop. *Indian J. Environ. Ecoplan*., 2: 43-46.

Pandey, D.D and A.K. Simba (1989). Effect of cement kiln dust on chlorophyll in gram leaves. *Indian J. Ecol.*, 16:178-179.

Pandey, D.D and A.K. Simba, (1990). Effect of cement kiln dust on chlorophyll in wheat leaf. *Environ. Ecol.*, 8: 461-463.

Peirce, G.J. (1910). An effect of cement dust on orange trees. *Plant World*, 13 : 283 288.

Prasad, M.S.V. and J.A. Inamdar (1990). Effect of cement kiln dust pollution on blackgram (*Vigna mungo* L.). *Proc. Indian Acad. Sci., (Plant Sci.),* 100: 435-443

Prasad, M.S.V., Subramanian, R.B andJ.A. Inamdar (1991). Effect of cement kiln dust on *Cajanus cajan (*L.) Mill. Species.*Indian Jr. Environ. Health*. 33: 11-21.

Raajasubramanian,D.,Sundaramoorthy,L..Baskaran,K.S.Ganesh, A.A. Chidambaram and M.Jeganathan (2011). Effect of cement dust pollution on germination and growth of ground nut (*Archis hypogaea* L.). *International Multidisplinary Research Journal*. 1/1:25-30.

Salami,A.T and A.I.Farounbi (2002).Effect of cement production on vegetation in a part of Southwestern Nigera.*Tanz.J.sci*,28 (2):69-82.

Santosh, K.P. and B. D. Tripathi. (2008). Seasonal variation of leaf dust Accumulation and pigment content in plant species exposed to urban particulates pollution. *J Environ Qual*. 37:865-870.

Satao, R.N., Kene, H.K., Nalamwar,R.V and R.B.Ulemale (1993). Effect of cement dust pollution on growth and yield of cotton. *Ann Plant Physiol*, 7: 73–77.

Schutzki, R.E. and B. Cregg. (2007). Abiotic Plant Disorders Symptoms, Signs and Solutions. A Diagnostic Guide to Problem Solving. *Extension Bulletin*. E-2996.

Shafiq, M and M.Z. Iqbal (1987). Plant sociology around the stone quarries and processing plants of Karachi and Thatta districts. *Inter J Ecol Environm Sci* ,13: 33-35.

Singh, S.N. and Rao, D.N. (1978). Effect of cement dust pollution on soil properties and on wheat plants. *India J. Environ. Hlth.* 20 : 258-267.

Singh,S.N and D.N. Rao (1980).Growth of wheat plants exposed to cement dust pollution,.*Water, Air & Soil Pollution* ,14: 241-249.

Singh,S.N and D.N.Rao.(1981).Certain responses of wheat plants to cement dust pollution.*Environmental Pollution*,24:75-81.

Singh, R.B (2000). Impact of stone crusher dust pollution on tomato (*Lycopersicum esculentum*) in the Sonbhadra district of U.P. *J. Environ. Poll.*, 7: 235-239.

Singh, R.B. and A.K. Shrivastava (2002). Cytotoxic effects and biological damages in *Clitoria ternatie* by cement dust.*Nat. Environ. Poll. Res.*, 1: 457-461.

Singh, P. and S. Jothi (1999). Reduction in protein contents in a few plants as indicator of air pollution. *Poll. Res.,* 18:281-283.

Sharifi, M. R., Gibson, A.C and P. W. Rundel (1997). Surface dust impacts on gas exchange in Mojave Desert shrubs. *Journal of Applied Ecology*, 34: 837-846.

Stern, A.C (1976). Air Pollution. *Measurement, Monitoring and Surveillance of Air Pollution,* 3rd ed., Academic Press, New York.

Stern, A.C. 1(976). Air Pollution, Measurement, Monitoring and surveillance of air pollution, 3rd ed., Academic press, Newyork.

Stratmann and Van Haut (1966). Studies on the effect of cement kiln dust on vegetation. *Air Pollution Control Association Journal*, 165(3): 33-39.

Sundaramoorthy, P., V. Venkatesalu, R. Arumugam and A. Rajesh (1997) Impact of cement kiln emission on *Tamarindus indica* L. *An ecological assessment. Proceedings on National Symposium on Tamarindus indica* L. Govt. of AP, Dept. of Forest, pp. 266-269.

Taylor, G. and W. J. Davies. (1990). Root growth of *Fagus sylvatica*: Impact of air quality and drought at a site in southern Britain. *New Phytologist*. 166: 457-464.

Thambavani S.D and Saravana K R. (2011). The monthly changes of chloroplast pigments content in selected plant species exposed to cement dust pollution. *Journal of research in Biology*. 8: 660-666.

Tinsley, I.J .(1979). *Chemical concepts in pollutant behavior*. Wiley Interscience, New York.

Treshow, M (1984). *Air pollution and plant life*. John Wiley and Sons, New York.

Tripathi, A.K and Mukesh Gautam (2007). Biochemical parameters of plants as indicators of air pollution. *J. Environ. Biol.*, 28: 127-132.

Uma, C.H and T.V.R. Rao (1996). Effect of cement kiln dust pollution on *Hibiscus cannabinus* L. *Geobios*, 23: 59-64.

Yunas, M., Dwivedi, A.K., Kulshreshtha, K and Ahmed K.J (1985). Dust loading on some common plants near Lucknow City. *Environmental Pollution (Series B)* 9: 7-80.

Zafar,M. I and M. Shafig (2001). Periodical effect of cement dust pollution on the growth of some plants species. *Turk.J.Bot.*, 25:19-24.