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Effect of industrial dust deposition on photosynthetic pigment chlorophyll and growth of selected plant species in Kalunga Industrial areas, Sundargarh, Odisha

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Abstract
The paper describes the effect of industrial dust on plants around Kalunga Industrial areas, of Sundargarh District, Odisha. Kalunga industrial is mostly known for the sponge iron and chemical factories. It is main hub for the production of steel and chemicals for the export in Odisha. Plant species growing in and around Industrial areas of Kalunga were selected within 2km far from the industries periphery. Various morphological characteristics and effect of dust on chlorophyll pigment were studied and observed the effect of dust particle on growth of the plant species. In the study the effects of industrial dust on selected tree species was observed and which will help tin managing development of green belt to reduce the air pollution in the study area.

Keywords: Air pollution, Sponge iron industries, Kalunga, Dust, Chlorophyll

1. Introduction
Air pollution which is a social disease generated due to human activities has become a major threat to the survival of plants in the industrial areas (Gilette, 1984; Gupta and Mishra, 1994) [20].
Poorly planned, rapid industrialization and automobile exhaust has led to different types of pollution and additions of the toxic substances to the environment are responsible for changing and disturbances in ecology (Mudd & Kozlowshi, 1975; Nirageue & Davidson, 1986; Clayton & Claton, 1982; Thambavani and Saravanakumar, 2011; 2012). [36, 38, 10, 50, 51] Dust emitted from different industries affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants (Joshi *et al.*, 2009; Farmer, 1993) [22, 23, 18]. Plants are the only living organisms, which have to suffer a lot from automobile exhaust and dust particle emitted from industries because they remain static at their habitat The plants are used as monitor of air pollution and also used as the first interceptors of air pollutants. Plants play main role in maintaining and determining the ecological balance by taking part in cycling of nutrients and gases like carbon dioxide and oxygen etc. (Steubing *et al*., 1989; Agbaire, 2009; Kumar & Nandini, 2013; Mahecha *et al.*, 2013) [57, 3, 61, 31]. The plants are used to reduce dust pollution as scavengers as they are initial acceptors of pollution for which, has been accepted in many countries such as London, Russia, Ohio, USA (Meetham, 1964; Novoderzhikina *et al.,*1966; Dochinger, 1980; Joshi & Swami, 2009, Randhi and Reddy, 2012; Mahecha, 2013) [49, 16, 22, 23, 45, 31]. The air pollution has a diverse effect on the morphological process such as colors, shapes, in the area. Ambient level of air pollution has been shown to affect stomatal opening and closing, photosynthesis apparatus damage and root morphology of young beech is due to dust accumulation on leaves (Taylor & Davis, 1990; Santosh and Tripathi, 2008) [59]. Leaves leaf length, width, area, petiole and physiological processes such as photosynthetic activities, mitochondrial respiration and stomatal clogging in plants (Miller *et al.*, 1973) [33]. Sponge iron industries play an important role in the environmental pollution by emitting dust particles and toxic substances to the environment as a result air pollution and ecosystem alteration occurs are very sensitive which affected by air pollutants during its development stages function as a good indicator to air pollutants (Leghari *et al*., 2013) [30].
Kalunga industrial is mostly known for the sponge iron and chemical factories. It is main hub for the production of steel and chemicals for the export in Odisha. Industrial emission from steel plant and sponge iron industries around Kalunga are the major sources of air pollution and deposition of dust on leaf surfaces. Due to increased dust deposition from industries and sponge iron plants has influenced the morphological and physiological aspect such as chlorophyll content of plants surrounding the sponge iron plants due to sponge iron plants. Previously studied have been done on Air pollution Tolerant Indices of different plants in Rourkela by different workers (Das *et al.*, 2010; Das and Prasad, 2010, Rai *et al*., 2013) [11-14, 45] but no work has been done in Kalunga Industrial area. This Kalunga industrial area comes under Rourkela-Kuarmunda-Birmitrapur-Kalunga-Rajgangpur industrial zone which is known as highly polluted area. A detailed study of the environmental literature revealed that with notable exception of few preliminary studies, no systematic work has so far been done to assesses the impact of sponge iron industries on chlorophyll of leaves. Present study has been carried out to know the changes in the concentration of chlorophyll content as well as morphological changes in the leaf samples of the plants collected from surrounding of sponge iron plants in the study area.

2. Materials and Method
2.1 Description of study Site
Kalunga, is an Industrial Estate, which is situated at outskirts from the Steel city Rourkela in Sundargarh district in Odisha. It is 8 km far from Rourkela area and 4 km from

Rajgangpur area. It is present at 22^0 13'21.39" N longitudes and 84^0 45'34.9"E latitude and above 145m above mean sea level. A total 105 nos. of sponge iron industries in Odisha, Sundargarh district has alone 46 sponge iron industries. A total 10 nos. of sponge iron industries out of 46 have been located in Sundargarh district. Species available within a radius of 2 km of the sponge iron plants were selected for analysis. (Table 1) They were selected from 3 different Sites: Site I- in and around the factory with in 500m; Site II- within a 1250m radius of the factory; Site III-(Control) 2000m away from the plant areas. Leaves of all species were collected from each Site thrice a week. Duplicates of fully mature leaves of each species were collected in the morning hours from trees of almost same diameter at breast height (DBH) and from the shrubs of almost same height.

Table 1: Description of study area

Sl.No.	Sampling Site	Location From Sponge Iron Plants	Category
1	Site I	500meter	Pollution
2	Site II	1250meter	Pollution
3	Site III	2000meter	Control

Plants studied: *Azadirachta indica, Cassia siamea, Dalbergia sisoo, Mangifera indica, Tamarindus indica, Calotropis procera, Lantana camara, Vitex negundo*

2.2 Collection of leaf Samples
Leaf samples were obtained from plants growing in different Sites in study area. Three replicates of fully matured leaves of each species were randomly collected in the morning 8 AM to 10 AM Samples were quickly transferred to the laboratory in polythene bag. The weight of fresh leaves was taken immediately and samples were preserved in a refrigerator for further analysis.

2.3 Morphology
To study the effect of sponge iron dust on morphological characters like the leaf length (cm), leaf breadth (cm), and leaf area (cm^2) was studied thoroughly in different Sites.

2.4 Dust Deposition
For the dust particulate estimation, deposited on the leaf surfaces 3 samples of leaves of each species were selected from different Sites. The initial fresh weight of leaf sample with dust particle was taken. Then the leaf sample was washed thoroughly distilled with water in beaker. Then the leaf samples were wiped with a clean cotton cloth and dried for few seconds. Then the dried leaf samples were again weighed and the final weight was calculated. The total amount of dust accumulation (mg) on the leaf surface was estimated by using formula:

$$W = \frac{W2-W1}{A}$$

Where,

W= total amount of dust content (mg/cm2).

W_1= Initial weight of the leaf sample with dust particles.

W_2= Final weight of the leaf sample without dust particles

A=Total area of leaf in cm^2

Total Chlorophyll content (TCH)
Total chlorophyll content analysis was done by following the method described by Arnon (1949) 0.5g of fresh leaves were blended and then extracted with 10 ml of 80% chiiled acetone and left for 15 min. The liquid portion was decanted and centrifuged at 2,500 rpm for 15 min. The supernatant was then collected and the abundance (Optical Density) was then determined at 645nm and 663nm using a spectrophotometer. Calculations were made using the formula given below:

Total Chlorophyll Content = (20.2XO.D. at 645nm) + (8.02XO.D at 663nm).

Where,

OD=Optical Density

3. Result and Discussion
3.1 Morphology
Morphological changes in leaf length, breadth and leaf area studied in three Sites is shown is table 2. From the study it showed the leaf length, breadth and leaf area in Site III (Control) is more than the other two Sites which are polluted Site. The reduction in size and length is due to dust deposition in Site I and Site II because these two Sites are nearer to industrial area.

Table 2. Morphological changes in plants during study in three Sites

		Leaf length (cm)			Leaf Breadth(cm)			Leaf area (cm2)		
Sl.No.	Species	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
1	*Azadirachta indica*	5.9	6.5	7.1	1.8	1.9	2	29	33	35
2	*Cassia siamea*	5.7	6.3	6.5	1.9	2	2.6	22	30	38
3	*Dalbergia sisoo*	4.2	5.8	6	4.9	5.2	5.4	42	51	52
4	*Mangifera indica*	16.2	18	20.8	4.5	5.3	6.5	86	99	137
5	*Tamarindus indica*	1.9	2	2.4	0.6	0.8	0.9	4.2	4.8	5.8
6	*Calotropis procera*	10.2	14	16	6.3	8.2	9.1	92	97	128
7	*Lantana camara*	4.9	5	6.4	2.8	3.2	3.6	54	60	70
8	*Vitex negundo*	6.2	7.2	7.6	1.8	2.1	2.4	45	48	51

3.2 Dust Deposition
Total dust deposition on selected plant species under study is shown in figure-1. All the plants studied in Site I exhibited highly dust deposition in comparison to Site II and Site III.

The highest dust deposition was on *Calotropis procera* (2.02 mg/cm^2) at Site I due to presence of pubescent hairs on leaf surfaces as well as area of leaf is more than other plant species while least deposition was *Tamarindus indica* (0.19).

In control, Site III, the selected plant species show reduction in dust deposition than other two Sites I and Sites II. The highest dust deposition was on *Azadirachta indica* instead of *Calotropis procera* in Site III. The Site III which is present 2000m far from the industrial periphery for which dust deposited less in compare to Site I and Site II. The plant species found in Site I accumulate heavy particulates deposition on their leaves surfaces due to their nearness to the sponge iron industries.

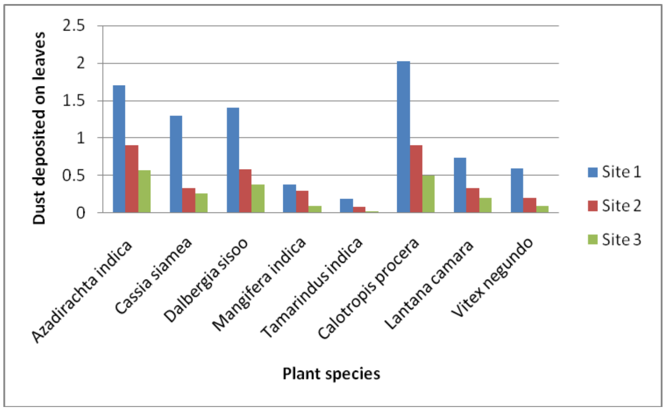

Fig 1: Total dust particle deposited on leaves (mg/cm^2) in three study Sites

3.3 Total Chlorophyll Content

Total chlorophyll content of studied plant species is shown in figure 2. All the plant species of Site III exhibited maximum amount of chlorophyll content. In Site I and Site II show very less amount of chlorophyll content. *Lantana camara* (3.16mg/g) showed highest chlorophyll content in comparison to other species in Site III as well as Site I and Site II. *Calotropis procera* (1.63mg/g) exhibited less amount of chlorophyll in comparison to chlorophyll present in *Tamarindus indica (*2.44mg/g*).* Due to broad in size the leaves of *C. procera* has more deposition of dust particles than *T. indica* leaves for which it showed in reduction of chlorophyll which indicates more size in leaves more dust deposition of dust particles. The variation in chlorophyll content is due to dust accumulation on leaf surfaces.

Photosynthesis is highly sensitive to air pollution; therefore measurement of chlorophyll in leaves is conceptually regarded as a useful diagnosis to determine the subtle pollutant effects. Chlorophyll is an index of productivity of plant (Bell and Mudd; 1976) [9] as well as development of biomass, is the principal photoreceptor in photosynthesis. The chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth (Raza and Murthy, 1988; Joshi and Swami, 2009) [47, 22, 23] It is well evident that chlorophyll content of plants varies from species to species; age of leaf and also with the pollution level as well as with other biotic and abiotic conditions (Katiyar and Dubey, 2001) [25]. Degradation of photosynthetic pigment has been widely used as an indication of air pollution (Ninave *et al*., 2001) [37]. The higher the levels of pollutants, the lower the chlorophyll content as certain pollutants in totality reduce the total chlorophyll content (Allen *et al.*, 1987) [6]. It is suggested that the pollutant gases such as SO2, NO2 and O3, produces oxy radicals in reaction with pollutants which causes damage to the membrane and associated molecules including chlorophyll pigment. (Leu horth and Dadd, 1981). The degradation of chlorophyll play a leading role in the tolerance of the plants to air pollution (Dedio, 1975) [15]. Hence higher the chlorophyll contents greater is the tolerance of plants to pollution. Rao and LeBlanc (1966) [46] have reported the degradation of Chlorophyll b due to the formation of chlorophyllide as SO_2 remove the phytol group of the chlorophyll b molecules. Strand (1993) [58] reported that photosynthetic pigment can also be affected at even low concentration of mixture of SO_2 and NO_2. Decrease in chlorophyll contents have been reported by Pandey and Pandey (1994) [40], Agarwal (2000) [1], Ramakrishnaiah and Somashekar (2003) [44], and Kumari *et al*., (2005) [28]. However Karthiyayini *et al*, (2005) [24] reported higher contents of chlorophyll in various plant species. Dust deposition also affects the presence of light for photosynthesis and decrease in chlorophyll content of leaves may be due to the alkaline condition created by dissolution of chemicals present in the dust particulates *i.e.*metals and polycyclic hydrocarbons in cell sap which block the Stomatal spores for diffusion of air and thus put stress on plant metabolism resulting in Chlorophyll degradation (Anthony 2001; Eller, 1977; Hope *et al.*, 1991; Keller and Lamprechet, 1995) [7, 17, 21, 26]. The reduction in the concentration of chlorophyll might have also been caused due to the increase in chlorophyllase enzyme activities which in turn effects the Chlorophyll concentration in plants (Mandal and Mukherjee, 2000) [32]. Studies on biochemical changes and impact of pollution on the plant metabolism as reduction in chlorophyll are important parameters in regulation of productivity (Ahmed and Qadir, 1975; Leghari *et al.*, 2014). Thus, all plant species undertaken for study were intermediately tolerant plants against pollution load and dust particulates.

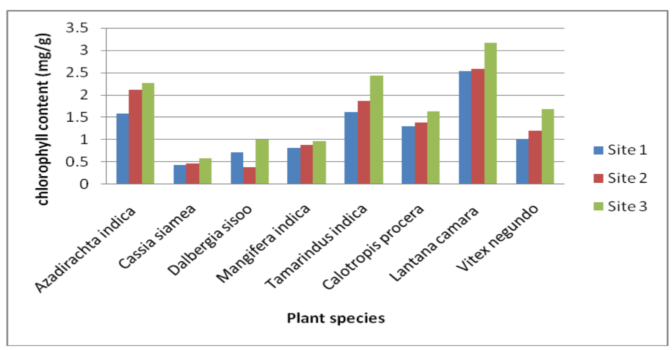

Fig 2: Total Chlorophyll Content studied in leaves (mg/g) in study Sites

4. Conclusion

A considerable loss in total chlorophyll in the leaves of plants exposed to pollution supports the argument that the chloroplast is the primary Site of attack by air pollutants such as $SO_2$and NO_x. This study indicates that exposure to particulate deposition alter the plant growth without changing any physical changes to the plant. Response of plants towards air is being assessed by air pollution tolerance index. Some plant species and varieties are so sensitive that they can be conveniently employed as biological indicators or monitors of specific pollutants. Besides study on impact of industrial dust particles on chlorophyll pigment of leaves, further research is going on other parameters to know the Air Pollution Tolerant indices of the plants in these areas which can further assist planner in managing the urban cities by developing green belt development to reduce the air pollution. In conclusion, it appears that tree plantation in industrial areas is Site specific activity and knowledge of tolerance level of plant species to air pollution is necessary for development of a green belt design a which will reduce the air pollution level as well as keep calm and clean and will helpful in beautification of the area.

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