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GROWTH OF *LEUCAENA LEUCOCEPHALA* (LAM.) DE-WIT, IN DIFFERENT SOILS OF KORANGI AND LANDHI INDUSTRIAL AREAS OF KARACHI, PAKISTAN

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Abstract

The effects of soils collected from Khan Towel, Tanveer Garment, One Tech Rubber and One Tech Ply Board factories in the vicinity of Korangi and Landhi industrial areas were studied on the growth of *Leucaena leucocephala* under natural environmental conditions in a greenhouse. Plants of *L. leucocephala* which were grown in soils of Tanveer Garment factory showed reductions in many of the growth variables like root length, shoot length, seedling length, plant cover, number of leaflets, leaf area and dry weights of root, shoot and leaf and total plant dry weight (which included root, shoot and leaf dry weights) as compared to plants grown in soil of a control area (Karachi University Campus soil). Khan Towel and One Tech Rubber factory soils caused decrease in the growth parameters such as number of leaflets and dry weights of root, shoot and leaf and total plant dry weight of *L. leucocephala* as compared to plants in control area soil whereas root/shoot ratio was reduced in plants which were grown in One Tech Ply Board factory soil over the control soil. Growth of *L. leucocephala* was mostly increased in soil of a control area when compared to soil of Tanveer Garment factory. The amount of total soluble salts and available sulfate in all of the industrial areas soils were higher relative to a control area soil of Karachi University Campus. Total soluble salts and copper were found in highest extent in the soil of Khan Towel factory as compared to a control area soil. Tanveer Garment factory soil had lowest organic matter and highest amount of zinc than control soil. In the case of One Tech Rubber factory, the amount of coarse sand and concentration of Calcium carbonate was mostly increased over the control soil whereas level of chromium was higher in One Tech Rubber factory soil than a control soil. Soil of One Tech Ply Board factory had highest magnitude of available sulfate relative to the control soil.

The research demonstrated that the growth of *L. leucocephala* was greatly reduced in plants which were grown in soil of Tanveer Garment factory than a control area soil of Karachi University Campus. Khan Towel and One Tech Rubber factory soils showed reductions in various growth variables of *L. leucocephala.* This showed that the soil of industrial areas of Korangi and Landhi, particularly of Tanveer Garment factory followed by Khan Towel factory and One Tech Rubber factory is contaminated by the existing pollution in the area.

Introduction

Environmental pollution is a constant threat to lives including plants. Rapid industrialization, motorization and phenomenal growth in population are creating an environmental pollution problem in Karachi city (Iqbal & Shafiq, 1999a). Karachi has three main industrial zones viz., Sindh industrial Trading Estate, Landhi Industrial Trading Estate and Korangi industrial area which emit excessive amount of industrial effluents and heavy metals into the air, water and land soil. In Karachi and Lahore cities of Pakistan, the major contributors to environmental degradation are industry (Anon., 1992). Industrial pollution is caused by the discharge of a variety of industrial pollutants in the form of gases, liquids and solids which affect the physical, chemical and biological conditions of the environment and are detrimental to human health, fauna, flora and soil properties (Dueck & Endendijk, 1987). Various kinds of industrial and automotive pollutants affecting the plants have been reported (Habib & Iqbal, 1996; Iqbal & Khalid, 1997). Tripathi (1978) and Bahadur & Sharma (1990) have studied the effect of industrial effluent on growth yield of various crops. *Leucaena leucocephala* is planted for ornamental purposes as well as sink for pollution in Karachi in the vicinity of polluted industrial areas. *L. leucocephala* is economically and medically an important plant (Iqbal *et al.*, 2001). It is a fast growing tree native to central America, with high protein in leaves (foliage) and is used for feeding dairy cattles (Iqbal & Shafiq, 1999b) has been introduced in the tropical countries including Pakistan for extraordinary amount of wood compared to many other plants (Khalid *et al.*, 1989). It is grown for fodder, but unless severely grazed or controlled, it spreads rampantly throughout the adjacent areas (Smith, 1985). Some studies of heavy metal pollution have been conducted on the growth of *L. leucocephala* plant at laboratory conditions to consider effects of heavy metals from different sources on the growth of plants. The toxic effects of cadmium (Iqbal *et al.*, 1991); lead (Iqbal & Siddiqui, 1992); lead (Pb) and cadmium (Cd) individually and in combination (Iqbal *et al.*, 2001); cadmium, lead, chromium and zinc (Iqbal & Atiq-ur-Rehman, 2002) on seed germination and seedling growth of *L. leucocephala* has been reported. A study of acid mist treatment was conducted on the growth of *L. leucocephala* to assume effects of acidic environment from various sources including industries on the growth of plants (Iqbal & Atiq-ur-Rehman, 2005a).

The physical and biological properties of soil need careful studies because soil is a natural medium for the plant growth and gives mechanical support to plant. Nazarian *et al.*, (2004) showed that the soil moisture, soil pH, organic matter, organic carbon (edaphic factors), slope, degree and altitude (topographic factors) from sea level of the region were principal ecological factors. The soil coarse sand, water holding capacity, organic matter, calcium carbonate, pH and available sulfate and heavy metals (Zn, Cu and Cr) were disturbed by industrial emission and affected the plant growth. Soil of industrial areas has been analyzed by many workers to investigate effects of soils on plants. Soil texture, maximum water holding capacity, $CaCO_3$, organic matter, pH were analyzed by Iqbal *et al*., (1983); Shafiq & Iqbal (1987); Mehmood & Iqbal (1995) in the vicinity of various industries. Soil was also analyzed for available sulfur (Iqbal & Zaman, 1993); whereas total soluble salts were examined along with moisture content, organic matter and pH (Wahab & Hashem, 1995) around different factories. Soil texture, organic matter, pH and concentration of $CaCO_3$ were also determined by Zaman & Iqbal (1994) along the sewage effluents channels of Malir river of Karachi which was polluted from different sources including industries. Soil around the industrial areas has also been used to detect the accumulation, deposition of metal pollution (Kuo *et al.*, 1983; Hunter *et al.*, 1987; Maxwell, 1991; Wahab & Hashem, 1995; Martinez & Motto, 2000). During growth, plants take up water and minerals through their roots from soil. Some workers demonstrated relation of different soil characters with plant. The soil pH also has an indirect effect on plants (Walter, 1971). Soluble salts produced a significant impact on the plant communities (Tivy, 1982). Changes in leaf water relations under water stress were examined by Saito & Terashima (2004). Sulphur is predominantly available to plants as sulphate in the soil and the sulphur demand is fulfilled by its uptake through the roots (Herschbach *et al.*, 2005). Metals effects were recorded on the growth of plants by some workers. Chromium ions interfere with growth of higher plants (Foroughi *et al.*, 1976). Stiborova *et al.*, (1987) observed the decrease in maize (*Zea mays* L.) biomass and inhibition in the activity of phosphoenolpyruvate carboxylae due to Cu, Cd and Pb ions.

Seedling growth and enzyme activities were found inhibited by zinc in *Phaseolus aureus* cv. R-851 (Veer, 1989). The excessive uptake of metals from soil reduced the yield of plants because of reduction in the metabolic and nutritional processes (Burzynski & Mereck, 1990; Hailing *et al.*, 1991; Chugh *et al.*, 1992).

Different types of industries including towel, garment, rubber and ply board etc. are present in the industrial areas of Karachi. These industries discharge different kinds of waste effluents and solid wastes which are polluting the soil of the nearby industries, thus causing deleterious effects to plants growing around the industrial areas. In view of the destructive and hazardous role of industries in Karachi, it is necessary to investigate the effects of polluted soil of industrial areas on growth of *Leucaena leucocephala*. Along the sewage effluents channels of Malir river (Karachi), some heavy metals were detected in soil, especially Pb (5-60 ppm), Cu (150-800 ppm) and Zn (20-360 ppm) which was polluted from the effluents of the industrial areas along with other sources, these heavy metals polluted soil influenced on the composition of growing plant communities at this area (Zaman & Iqbal, 1994).

In the present study, the effects of polluted soil of industrial areas of Korangi and Landhi on the growth of *Leucaena leucocephala* were examined since the plant grows in the vicinity of the industrial areas.

Materials and Methods

The experiment was conducted in greenhouse under the uniform natural environmental conditions at the Department of Botany, University of Karachi. *Leucaena leucocephala* (Lam.) de Wit, of the family Mimosaceae is a leguminous tree and is cultivated around roadsides and industrial areas of Karachi. Healthy and uniform-sized seeds of *L. leucocephala* were collected from a control area of Karachi University Campus. Because of hard seed coat in *L. leucocephala*, the seeds were slightly cut at one end for mechanical scarification and were sown in garden soil at 1 cm depth of soil in large pots and irrigated daily. After some period, uniform-sized seedlings were transplanted in pots of 19.8 cm in diameter and 9.6 cm in depth in Khan Towel factory, Tanveer Garment factory, One Tech Rubber factory and One Tech Ply Board factory of Korangi and Landhi industrial areas of Karachi for eight weeks. The Karachi University soil was used as a control. *L. leucocephala* plants were grown in 50% above-mentioned soils which were mixed with 50% garden soil (one part manure + two parts fine sand in each soil type). In the preliminary studies pure soils of all industries collected from Korangi and Landhi areas hardly showed any response to seed germination and seedling growth. It was therefore decided to take half of the soil of the respective area and mixed with 50% garden soil. There were six replicates for each soil. The experiment was completely randomized. Only one seedling was grown in each pot and the plants were irrigated daily. Every week reshuffling of pots were also carried to avoid light/shade or any other greenhouse effects. Daily climatic data, as average temperature, atmospheric relative humidity, weather out look and sun shine were recorded (Appendix 1). Seedlings height and number of leaves were recorded after every two weeks for 8 weeks in the experiment. Plant of *L. leucocephala* was carefully removed from the pots soils after 8 weeks and washed thoroughly to measure root length (cm), shoot length (cm) seedling length (which included length of root and shoot) (cm), plant cover (plant circumference) (cm), number of leaflets and leaf area (sq cm) from different soils. Root, shoot and leaves were separated to dry in an oven at 80 °C for 24 hours. Oven-dried weights of root (g), shoot (g), leaves (g) and total plant dry weight including root, shoot and leaf dry weights (g) were determined. Root/Shoot ratio, leaf weight ratio, specific leaf area ($cm^2\ g^{-1}$) and leaf area ratio ($cm^2\ g^{-1}$) were also determined as follows:

Determination of growth variables

$$\text{Root/Shoot ratio} = \frac{\text{Root dry weight}}{\text{Shoot dry weight}}$$

$$\text{Leaf weight ratio} = \frac{\text{Leaf dry weight}}{\text{Total plant dry weight}}$$

$$\text{Specific leaf area } (cm^2\ g^{-1}) = \frac{\text{Leaf area}}{\text{Leaf dry weight}}$$

$$\text{Leaf area ratio } (cm^2\ g^{-1}) = \frac{\text{Leaf area}}{\text{Total plant dry weight}}$$

In another study, two soil samples from the various factories were obtained from 0-30 cm depths, including soil samples from the control area of Karachi University Campus. Soil samples were stored in labeled polythene bags and brought to the laboratory. Later the samples were air-dried, lightly crushed and passed through a 2 mm sieve and kept in the laboratory for analysis. For mechanical analysis of soil, coarse sand was determined using 0.05 mm sieve (Anon., 1951). Maximum water holding capacity (W.H.C.) in % was measured by the method of Keen (1931). Soil organic matter in % was determined according to Jackson (1958). Calcium carbonate ($CaCO_3$) concentration in % was determined by acid neutralization as described by Qadir *et al.*, (1966). Bower & Wilcox (1965) methodology was used to determine total soluble salts in %, whereas**,** soil pH was recorded by a direct MP 220 pH Meter (Mettler, Toledo). Available sulfate in soil was determined in μg^{-g} by the turbidity method as described by Iqbal (1988), using a colorimeter (Photoelectric Colorimeter AE-11M). Soil analysis was also conducted for heavy metals. Where, all the soil samples were wet digested. One gram dried soil sample was taken in 50 ml beaker and digested with 5 ml concentrated nitric acid (HNO_3) + 5 ml concentrated perchloric acid ($HClO_4$), heated at 90 °C for 2½ hours. Thereafter, little amount of distilled water was added in the digested residue and filtered through Whatman filter paper No. 42 and solution volume was made up to 50 ml using distilled water and solution was diluted 10 times for metal like copper (Cu), zinc (Zn) and chromium (Cr) analyses. Heavy-metal analyses of soils in (μg^{-g}) were accomplished *via* atomic absorption spectrophotometer (Perkin Elmer Model No. 3100).

Data of various growth parameters of *L. leucocephala* and data of different variables of soil samples was statistically analyzed by ANOVA (Steel & Torrie, 1984) and DMRT (Duncan, 1955) ($p<0.05$) using a personal computer software package Costat version 3 and SPSS version 10.0.

Reduction in percentage of different variables of *L. leucocephala* was determined in different polluted factory soils relative to the control soil of Karachi University Campus using the following formula:

$$\text{Percentage reduction (\%)} = \frac{\text{Mean value for control soil (Karachi University)} - \text{Mean value for treated (factory) soil}}{\text{Mean value for control soil (Karachi University)}} \times 100$$

Appendix 1. Climatic Data of Karachi During the Growth of *Leucaena leucocephala* (2.7.03-27.8.03).

Dates	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Atmospheric relative humidity (%)	Sun shine (Hours)	Weather out look
2.7.03	33	28	31	70	13:41	Mostly cloudy
3.7.03	33	28	31	66	13:41	Mostly cloudy
4.7.03	32	28	30	66	13:40	Mostly cloudy
5.7.03	31	27	29	ND	13:40	Mostly cloudy, rain
6.7.03	31	28	30	70	13:39	Mostly cloudy, rain
7.7.03	31	28	30	79	13:38	Mostly cloudy, rain
8.7.03	ND	ND	ND	ND	13:38	ND
9.7.03	30	28	29	79	13:37	Mostly cloudy, rain
10.7.03	31	28	30	79	13:37	Mostly cloudy, rain
11.7.03	32	26	29	79	13:36	Mostly cloudy, rain
12.7.03	32	26	29	74	13:41	Mostly cloudy
13.7.03	32	26	29	70	13:35	Partly cloudy
14.7.03	32	27	30	75	13:34	Cloudy
15.7.03	32	27	30	70	13:34	Partly cloudy
16.7.03	31	27	29	71	13:33	Mostly cloudy, rain 8.43mm
17.7.03	30	27	29	89	13:33	Mostly cloudy, rain
18.7.03	31	27	29	89	13:36	Mostly cloudy, rain
19.7.03	31	27	29	79	13:31	Mostly cloudy, rain
20.7.03	35	28	32	67	13:30	Sunny
21.7.03	31	27	29	79	13:29	Mostly cloudy
22.7.03	31	27	29	74	13:27	Mostly cloudy, rain
23.7.03	31	27	29	79	13:27	Mostly cloudy, rain
24.7.03	30	26	28	70	13:26	Mostly cloudy, rain
25.7.03	29	26	28	79	13:26	Mostly cloudy, rain
26.7.03	30	26	28	84	13:25	Mostly cloudy, rain
27.7.03	31	26	29	84	13:24	Mostly cloudy, rain
28.7.03	30	26	28	79	13:22	Mostly cloudy, rain
29.7.03	30	26	28	94	13:22	Mostly cloudy, rain
30.7.03	29	26	28	ND	13:21	Mostly cloudy, rain
31.7.03	30	26	28	89	13:19	Cloudy
1.8.03	31	26	29	74	13:19	Mostly cloudy, rain
2.8.03	31	26	29	89	13:17	Mostly cloudy, rain
3.8.03	31	26	29	70	13:17	Mostly cloudy, rain
4.8.03	30	26	28	74	13:15	Mostly cloudy, rain
5.8.03	30	26	28	79	13:14	Mostly cloudy, rain
6.8.03	31	26	29	79	13:13	Mostly cloudy, rain
7.8.03	31	26	29	79	13:12	Mostly cloudy, rain
8.8.03	32	26	29	84	13:10	Partly cloudy
9.8.03	31	26	29	74	13:10	Partly cloudy
10.8.03	31	26	29	74	13:08	Partly cloudy
11.8.03	31	26	29	70	13:07	Partly cloudy
12.8.03	31	26	29	74	13:06	Partly cloudy
13.8.03	31	26	29	66	13:05	Partly cloudy
14.8.03	31	26	29	66	13:04	Partly cloudy
15.8.03	ND	ND	ND	ND	ND	ND
16.8.03	31	26	29	66	13:01	Partly cloudy
17.8.03	31	26	29	66	12:59	Partly cloudy
18.8.03	31	26	29	70	12:58	Partly cloudy
19.8.03	31	26	29	74	12:58	Partly cloudy
20.8.03	31	26	29	70	12:55	Partly cloudy
21.8.03	31	26	29	79	12:55	Partly cloudy
22.8.03	32	26	29	84	12:53	Partly cloudy
23.8.03	33	27	30	74	12:52	Mostly cloudy
24.8.03	32	27	30	62	12:51	Mostly cloudy
25.8.03	30	27	29	79	12:49	Mostly cloudy, rain
26.8.03	30	26	28	84	12:48	Mostly cloudy, rain
27.8.03	30	26	28	79	12:46	Partly cloudy

ND: Not Determined, Source: Daily Dawn news paper 2003

Percentage reduction in soil properties (coarse sand, water holding capacity, organic matter, $CaCO_3$, total soluble salts, pH and available sulfate and Cu, Zn and Cr) of various factory soils in comparison with the control soil of Karachi University Campus was also determined using the above-mentioned formula.

The growth of *L. leucocephala* was correlated with analyzed soil characters of coarse sand, water holding capacity, organic matter, $CaCO_3$, total soluble salts, pH, available sulfate, Cu, Zn and Cr.

Results

Little difference was found in seedling height and number of leaves of *Leucaena leucocephala,* after second week when plants were growing in soil of different areas (Figs. 1a and 1b), afterward, after every two weeks, the height of *L. leucocephala* gradually increased and after eight weeks, the height and number of leaves differed in soils of different areas. At the final week, Tanveer Garment factory soil showed lowest height of 16.83 cm (Fig. 1a) and number of leaves of 31.67 (Fig. 1b) in plant of *L. leucocephala* as compared to (20.97 cm) height and number of leaves (32.17) in a control area soil of Karachi University Campus.

The reduction in most of the growth parameters such as root length, shoot length, seedling length (which included length of root and shoot), plant cover (plant circumference), number of leaflets, leaf area and dry weights of root, shoot and leaf and total plant dry weight (which included root, shoot and leaf dry weights) of *L. leucocephala* was higher when plants were grown in Tanveer Garment factory soil as compared to plants of *L. leucocephala* which were grown in a control area soil (Table 1a and 1b and Table 2). Soil of Tanveer Garment factory which caused suppressed growth in many variables of *L. leucocephala* had decreased amount of organic matter and increased concentration of Calcium carbonate, total soluble salts and available sulfate, copper and zinc over the control area soil of Karachi University area (Table 3 and Table 4).

Khan Towel factory soil reduced the growth variables like root length, seedling length, number of leaflets and dry weights of root, shoot, leaf and total plant dry weight of *L. leucocephala* than plants grown in control soil. In soil of Khan Towel factory, high amount of $CaCO_3$, total soluble salts, available sulfate, copper and Zn was observed as compared to control area soil.

In case of One Tech Rubber factory soil, plants of *L. leucocephala* showed decreased growth like number of leaflets and dry weights of root, shoot and leaf and total plant dry weight as compared to plants grown in control soil. Decreased water holding capacity, organic matter and high amount of coarse sand, $CaCO_3$, total soluble salts and available sulfate and Cr were recorded in soil of One Tech Rubber factory relative to control soil.

One Tech Ply Board factory soil retarded the root/shoot ratio in plant of *L. leucocephala.* Soil of One Tech Ply Board factory had high amount of total soluble salts and available sulfate and copper than a control area soil of Karachi University Campus.

Discussion

Soils of industrial areas particularly Tanveer Garment factory soil mostly affected the growth of *Leucaena leucocephala* as compared to control area soil of Karachi University Campus. Atiq-ur-Rehman & Iqbal (2006) found that when plants of *L. leucocephala* were treated with soil extracts of various factories in laboratory conditions then extract of soil of Tanveer Garment factory induced percentage reductions in many growth variables like seed germination (60.9%), root (84.2%), shoot (54.1%) and seedling length which included length of root and shoot (72.2%) of *L. leucocephala* over the soil extract of the control area Karachi University Campus soil.

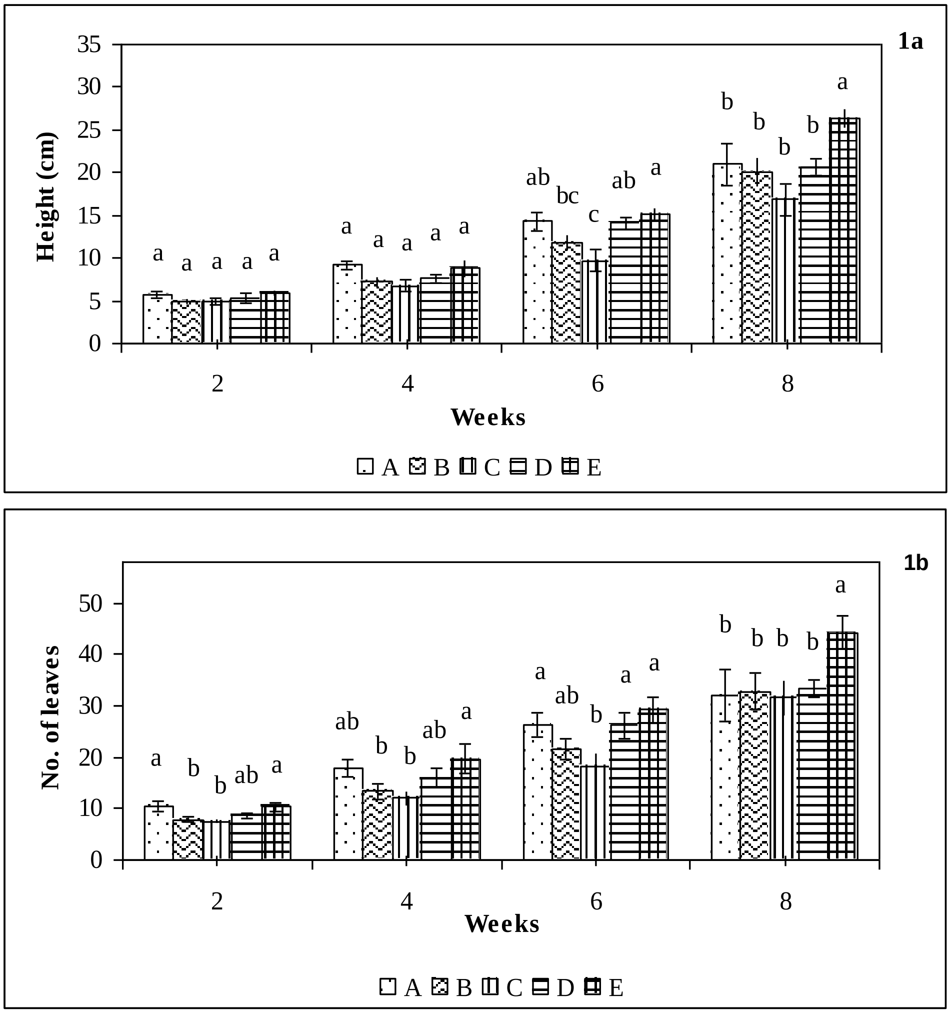

Fig. 1a & b: Periodical height (cm) and number of leaves of *Leucaena leucocephala* in soils of different areas.

A = Karachi University; B = Khan Towel factory; C = Tanveer Garment factory; D = One Tech Rubber factory; E = One Tech Ply Board factory.

In each soil type, 50% soil was mixed with 50% garden soil.

Statistical significance determined by analysis of variance. Number followed by the same letters in each periodical height and number of leaves are not significantly different ($p < 0.05$) according to Duncan's Multiple Range Test.

I Standard error

Plants directly depend on the soil characteristics and conditions necessary for their successful growth. The plant growth of *L. leucocephala* was significantly associated with coarse sand, water holding capacity of soil, pH, organic matter, calcium carbonate, total soluble salts, available soil sulfate and heavy metals (copper, zinc and chromium) and increase and decrease in these soil characteristics caused by Korangi and Landhi industries produced a significant impact on the plant growth. Higher amount of coarse sand and lower amount of water holding capacity in soil of One Tech Rubber factory caused reduction in the growth of *L. leucocephala.* Soil texture and water holding capacity showed marked correlation and influenced the growth of *L. leucocephala* in One Tech Rubber factory soil. Soil organic matter was high in soil of a control area (Karachi University Campus soil) as correlated with Tanveer Garment and One Tech Rubber factory soils. High organic matter caused improved growth in plants as determined by Singh (1986). He observed that in those plant communities (group of plants) which had a higher percentage of soil organic matter, the water holding capacity of soil was consequently increased due to the colloidal nature of the organic matter. Pakistani soils are extremely low in organic matter (Ladha *et al.,* 1996; Zia *et al.,* 1998; Bhatti, 1999; Aslam *et al.,* 2000). The concentration of Calcium carbonate was higher in Khan Towel, Tanveer Garment and One Tech Rubber factories soils relative to the control soil. An appreciable amount of Calcium carbonate (9.8 - 17.1%) is the characteristic features of arid zone soils (Aubert, 1960). Total soluble salts and available sulfate in all of the industrial soils was higher as compared to control soil of Karachi University Campus which caused the reduction in various growth variables in factories soils. Salinity is a major yield–limiting factor for crops in all the arid and semiarid regions of the world (Flores *et al.,* 2004). High amount of available sulfate reduces the plant growth and absorbed sulphur in the form of sulfate which is obtained from industrial emission of SO_2 in excessive amount. Exposure to constant concentration of SO_2 caused notable and significant reductions in the dry matter accumulation and yield of *Lolium perenne* L. cv. S23 (Ashenden & Mansfield, 1977; Bell *et al.,* 1979).

High amount of copper was found in soils of most of the industries like Khan Towel, Tanveer Garment and One Tech Ply Board factories than in control area soil of Karachi University Campus. Some metals such as Cu, Co, Fe, Mo, Mn, Ni and Zn are essential mineral nutrients (Shafiq & Iqbal, 2005). Plants have a natural propensity to take up these metals and low amount need to plant but higher level is toxic. These metals are discharged into the air by anthropogenic (man-made) activities. Excess copper inhibits plant growth and high levels of Cu occur as a result of the anthropogenic release of heavy metals into the environment through mining, smelting, manufacturing (industries), agriculture and waste disposal technologies (Yruela, 2005). Copper and ferric treatments greatly reduced the germination percentage of *Albizia lebbeck* seeds, particularly at the higher concentrations of 300, 500, 700 μg^{-ml} than lower concentration of 100 μg^{-ml} (Iqbal & Atiq-ur-Rehman, 2005b). Zinc was high in Khan Towel and Tanveer Garment factory soils than control soil which may be the cause of reductions in the growth of *L. leucocephala.* These metals (Cu, Zn and Cr) are high in the vicinity of industrial areas of Korangi and Landhi which are obtained from the emissions of industrial by-product and accumulated in soil then from soil into plants parts like root, shoot and leaves etc. Atiq-ur-Rehman *et al.,* (2007) reported that the levels of different metals (Fe, Cu, Zn & Cr) were mostly higher in plants of *L. leucocephala* which were grown in soil of industrial areas than a control area soil of Karachi University Campus. Kashem & Singh (1999) reported that in correlation matrix, plant concentrations of Cu, Mn, Pb and Zn were significantly correlated with their total and extractable contents in soils and the concentrations of most heavy metals were also higher in the vegetation samples of leather industry area. Zinc produced by the industries was investigated by some workers. Valee & Ulmer (1990) expressed that Zn is used in the industries for many purposes. Kartal *et al.,* (1993) reported that Pb, Cd and Zn pollution was very high, originating from the zinc ore used in the factory (Cinkur plant) in Kayseri, in Turkey. Iqbal & Shafiq (1999c) have reported adverse effects of Cu and Zn on seed germination and seedling growth of wheat.

Chromium is a toxic metal for plant growth and its higher level in soil of One Tech Rubber factory as compared to control soil of Karachi University Campus caused growth reduction in *L. leucocephala*. Iqbal & Atiq-ur-Rehman (2002) determined that the increase in concentration of Cr reduced the dry weight of *L. leucocephala.* The uptake of Cr (VI) by the plant gradually increased with increase in concentration of Cr (VI) in the tannery effluents (Sen *et al.*, 1994).

The dry biomass of root, shoot, leaf and total plant which included root, shoot and leaf of *L. leucocephala* was more affected from most of the industrial soils of Khan Towel, Tanveer Garment and One Tech Rubber factories soil as compared to other variables. The suppression in dry weight of *L. leucocephala* was observed with increase in concentration of chromium (Iqbal & Shafiq, 1999b).

In soil of One Tech Ply Board factory different growth variables of *L. leucocephala* was increased which might be due to high water holding capacity, organic matter and decreased concentration of $CaCO_3$ and zinc as compared to control soil. Singh & Singh (1990) studied the germination of spruce and silver fir in relation to covering media. In these two species seed covered with humus gave higher germination and better growth of seedlings than nursery soil, river sand and saw dust. High organic matter provided nutrient availability for plant metabolisms consequently, plant growth was increased. However, One Tech Ply Board factory soil was somewhat better for plant growth of *Leucaena leucocephala* as compared to other factories soils.

The present studies would suggest that the soil of the industrial areas of Korangi and Landhi is not good for plant growth. However, if soils of industrial areas are mixed with garden soil, the plants showed better growth in soil as observed in One Tech Ply Board factory soil. In this soil, many growth variables of *L. leucocephala* were increased whereas mixture of garden soil also supported increase in growth of *L. leucocephala*. Similar results were also observed by Atiq-ur-Rehman (2006) in One Tech Ply Board factory soil. He examined that different variables of *T. populnea*, *P. pterocarpum*, *Azadirachta indica* and *Prosopis juliflora* (Korangi and Landhi industrial areas population) were increased in growth in One Tech Ply Board factory soil than other factories soils.

Thus, *Leucaena leucocephala* was a sensitive plant species for soils of industrial areas particularly with respect to Tanveer Garment factory soil. Therefore, *L. leucocephala* should not be grown in the vicinity of Korangi and Landhi industrial areas. Tolerant cultivated plants should be selected to grow in the vicinity of Korangi and Landhi industrial areas of Karachi as Atiq-ur-Rehman & Iqbal (2006) suggested that *Peltophorum pterocarpum* should be planted in the vicinity of Korangi and Landhi industrial areas of Karachi. Atiq-ur-Rehman (2006) also suggested that along with *P. pterocarpum, Thespesia populnea* is also tolerant plant species in soil of Korangi and Landhi industrial areas as compared to other plants species studied. Iqbal & Shafiq (1999b) reported that *Ricinus communis* is a more tolerant plant species as compared to *L. leucocephala,* therefore *R. communis* should be planted around the industrial areas of Karachi. In other industrial area, tolerant tree species should be chosen according to the level of industrial pollution.

The findings of this research could be helpful in monitoring and controlling the pollutant levels in soils of the industrial areas. Furthermore, such information could also be useful for landscaping and urban planning.

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