Growth of *Albizia lebbeck* (L.) Benth. (Mimosaceae) in Polluted Soils of Landhi and Korangi Industrial Areas of Karachi, Pakistan

Syed Atiq-ur-REHMAN [1]
Muhammad Zafar IQBAL [2]
Mohammad ATHAR [3](✉)

Summary

Growth of *Albizia lebbeck* was observed in the polluted soils from towel, garment, rubber and ply board factories in the vicinity of Landhi and Korangi industrial areas of Karachi. Growth of *A. lebbeck* was reduced in most of the industrial area soils as compared to the control soil from Karachi University campus. The rubber factory soil reduced all the growth parameters as compared to the control soil. Percentage of soil pollutants (total soluble salts and available sulfate) in all of the industrial area soils was higher than in the control area soil. Percentage of coarse sand, calcium carbonate, total soluble salts, available sulfate, and chromium was higher in soil of rubber factory then in the control area soil whereas percentage of water holding capacity, organic matter and zinc was lower in soil from rubber factory than in the control area soil. This showed that the soil of industrial areas of Landhi and Korangi particularly from rubber factory and ply board factory was contaminated by the pollutants in the area and drastically affected the plant growth. The findings of this research could be helpful in monitoring and controlling the pollutant levels in soils of the industrial areas. Such information could also be useful for landscaping and urban planning.

Key words

Albizia lebbeck, plant growth, industrial soil, soil pollutants, heavy metals, soil physical and chemical properties

[1] Govt. Degree College, Department of Botany, Buffer Zone, Karachi-75850, Pakistan
[2] University of Karachi, Department of Botany, Karachi- 75270, Pakistan
[3] California Department of Food and Agriculture,
3288 Meadowview Road, Sacramento, CA 95832, USA
✉ e-mail: atariq@cdfa.ca.gov

Received: February 9, 2011 | Accepted: May 21, 2011

Introduction

Environmental pollution is a constant threat to humanity. Numerous researchers have described the damages to vegetation caused by industrial effluents particularly to the crop plants (Camplin, 2001; Clemente et al., 2005; Davies and Linsey, 2001; Gren and Trett, 2000; Yasir 2003). Iqbal and Qadir (1973) determined the effect of industrial pollution on seed germination. Significant reduction in seed germination, root and shoot length was observed in seeds collected from the polluted area as compared to clean areas. Relationship among the dominant species to the edaphic factors indicated that physical properties of soil such as soil strength, bulk density, texture and structure greatly influence the root penetration, growth and yield of various crops (Gerad et al., 1982). Trace metals present in the environment are hazardous to ecological systems and also to human health and plant growth (Shafiq and Iqbal, 2005 a). Zaman and Iqbal (1994) detected some heavy metals especially lead, copper and zinc in soil that was polluted from the effluents of the industrial areas. Karachi is an industrial city, as well there is automobile pollution in the surrounding of road side areas due to auto-vehicles producing damaging and perilous contaminants like unburned and incompletely burned hydrocarbons, toxic carbon particles, black smoke due to incomplete combustion of fuel and tar materials, other elements and lead compounds by lubricant oils and petrol that settled down on plant surface. Urban areas trees causing a sever limitation of plant able space and an conspicuously smashup growing environment like green sites, tress desolation, lands scape pressure, degradation of environment, congestion of traffic and air pollution and to accommodate cities progress which repress performance and reduction of life extent (Jehan and Iqbal, 1992; Webb, 1998). Plant growth and seed germination are greatly affected by abnormal metabolic process due to contaminants of auto-exhaust (Türkan, 1988; Mahmood and Iqbal, 1989; Qadir and Iqbal, 1991). Iqbal (1988) has investigated the amount of sulphur in soil and foliage of roadside areas and plantation. Different types of industries including towel, garment, rubber and ply board are present in the industrial areas of Karachi. These industries discharge different kinds of waste effluents and solid wastes that are polluting the soil of nearby industries causing deleterious effects on the plants growing around the industrial areas. In view of protecting the environment from the destructive and hazardous role of industries in Karachi, it is imperative to investigate the effects of polluted soil of industrial areas on the vegetation prevalent in the area.

Albizia lebbeck (L.) Benth. is a leguminous tree in family Mimosaceae and it is cultivated around roadsides and industrial areas of Karachi. The present study was aimed at determining the effect of polluted soil from industrial areas of Landhi and Korangi on the growth of *A. lebbeck*.

Materials and methods

The experiment was conducted in greenhouse under the uniform natural environmental conditions at the Department of Botany, University of Karachi. Healthy and uniform-sized seeds of *A. lebbeck* were collected from the plants growing at the University of Karachi. Due to hard seed coat the seeds were slightly cut at one end for mechanical scarification. Seeds were sown at 1 cm depth in garden soil filled in large pots and irrigated daily.

Industrial soil was collected from the towel factory, garment factory, rubber factory and ply board factory located at Landhi and Korangi industrial areas of Karachi. Actual names of the factories were deliberately omitted to protect the privacy of the industry. In a preliminary study, it was observed that pure soils from all industrial areas of Landhi and Korangi hardly showed any response to seed germination and seedling growth. The industrial area soil was therefore individually mixed with 50% garden soil containing one part manure + two parts fine sand. Seedlings of uniform-size were transplanted in pots (19.8 cm diam., 9.6 cm deep) filled with ameliorated industrial soil. One seedling was grown in each pot and the plants were irrigated daily with tap water. Soil from Karachi University campus served as a control. There were four replicates for each soil. The experiment was completely randomized. Pots were reshuffled every week to avoid light, shade or any other greenhouse effects. Plants were carefully removed from the pots after five weeks, washed thoroughly and growth parameters were recorded. Dry weight of root, shoot and leaves was determined after drying in an oven at 80°C for 24 hours. Root/shoot ratio, leaf weight ratio, specific leaf area and leaf area ratio were also calculated.

In another study, two soil samples were collected at 0-30 cm depths from various factories including soil samples from the control area. 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. Physical and mechanical analysis of soil was done following Dane (2002). Coarse sand was determined by sieve method using 0.05 mm sieve. Soil organic matter was determined according to Jackson (1958). Calcium carbonate concentration was determined via acid neutralization as described by Qadir et al. (1966). Bower and Wilcox (1965) methodology was used to determine total soluble salts whereas soil pH was recorded via a direct pH-reading meter (MP 220 pH Meter, Mettler, Toledo). Available sulfate in soil was determined by turbidity method, using a colorimeter (Photoelectric Colorimeter AE-11M), as described by Iqbal (1988). Heavy metals in the soils were analyzed by wet digestion of all the soils followed by atomic absorption spectrophotometer (Perkin Elmer Model No. 3100). For this intention, in 50 ml beaker, one gram dried soil sample was used and added 5 ml concentrated perchloric acid ($HClO_4$) + 5 ml concentrated nitric acid (HNO_3), for digestion and after that heated at 90°C for 2½ hours. In the digested residue little amount of distilled water was added then Whatman filter paper No. 42 was used for filtration and made up to 50 ml solution volume using distilled water and 10 times diluted solution for copper, zinc and chromium analyses by atomic absorption spectrophotometer (Perkin Elmer Model No. 3100).

Statistically analysis of all data was also conducted by ANOVA (Steel and Torrie, 1984) and DMRT (Duncan, 1955) ($p < 0.05$) by personal computer software packages Costat version 3.0.

Reduction in percentage of different variables of *A. lebbeck* was determined in polluted factory soils as compared to the control soil from Karachi University campus. Percentage reduction in soil properties (coarse sand, water holding capacity, organic matter, calcium carbonate, total soluble salts, pH, available sulfate and copper, zinc and chromium) of various factory soils was determined in comparison with the control soil. Percentage reduction in growth of *A. lebbeck* was correlated with percentage reduction of analyzed soil characters.

Results and discussion

All the industrial soils reduced most of the growth variables of *A. lebbeck* as compared with the control area soil from Karachi University campus (Tables 1-2). *A. lebbeck* is planted for ornamental purposes as well as sink for pollution in Karachi in the vicinity of polluted road sides and industrial areas (Iqbal and Rehman, 2005). Industries are the major contributors to environmental degradation in Karachi and Lahore (WHO/UNEP, 1992). Various kinds of industrial pollutants affecting the plants growth have been studied by some researchers (Iqbal and Khalid, 1997; Habib and Iqbal, 1996).

Plants directly depend on the soil characteristics and conditions necessary for their successful growth. The plant growth was significantly associated with coarse sand, water holding capacity of soil, pH, organic matter, calcium carbonate, total soluble salts, and available soil sulfate. Any increase and decrease in these soil characteristics showed a significant impact on the plant growth. Edaphic factors of Landhi and Korangi industrial areas affected the plant growth of *A. lebbeck*. Percentage of soil pollutants (total soluble salts and available sulfate) in all the industrial soils was higher relative to the control soil (Tables 3-4). High amount of available sulfate absorbed reduces the plant growth. Sulphur is absorbed in the form of sulfate that is obtained from industrial emission of SO_2 in excessive amount. It has been reported that 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 and Mansfield, 1977; Bell et al., 1979). High amount of available sulfate may reduce the growth of *A. lebbeck* from soils of industrial areas. The growth of *A. lebbeck* was increased in soil of control area as compared with industrial area soils which may be due to low amount of total soluble salts and available sulfate in the control soil. Sulfur is predominantly available to plants as sulfate in the soil and the sulfur demand is fulfilled by its uptake through the roots (Herschbach, 2003; Herschbach et al., 2005). Control and industrial soils displayed to some extent basic pH value with slight variations which represent alkaline or saline nature of soil at the control and industrial polluted areas of Karachi. Some metals such as copper, cobalt, iron, molybdenum, manganese, nickel and zinc are essential mineral nutrients (Shafiq and Iqbal, 2005a). Plants have a natural propensity to take up these metals in low amount but higher levels are toxic to plant growth. Higher amounts of copper were observed in soils of most of the industrial area soils than the control soil. Higher levels of copper occur as a result of the anthropogenic release of heavy metals into the environment through mining, smelting, manufacturing, agricultural and waste disposal technologies (Yruela 2005). Copper and ferric treatments greatly reduced the germination of *A. lebbeck* seeds, particularly at the higher concentrations (Iqbal and Rehman 2005). Zinc was high in towel factory and garment factory soils which reduced the growth of *A. lebbeck*. The metals like copper, zinc and chromium were high in the vicinity of industrial areas of Landhi and Korangi where they are emitted by industrial by-product. Rehman et al. (2007) conducted a study of metals accumulation in plants of *Leucaena leucocephala* and reported high levels of iron, copper, zinc and chromium in *L. leucocephala* grown in soil of industrial areas and in Karachi University campus soil. Their study showed that the soil of the industrial areas of Landhi and Korangi particularly of rubber and ply board factories was contaminated by the existing pollution in the area. Zinc is used in the industries for many purposes (Valee and Ulmer, 1990). Kartal et al. (1993) reported that lead, cadmium and zinc pollution was very high, originating from the zinc ore used in the factory (Cinkur plant) in Kayseri, in Turkey. Kashem and Singh (1999) conducted a study to investigate the heavy metal contamination of soil and vegetation in the vicinity of industries around Dhaka in Bangladesh. They reported that plant concentrations of copper, manganese, lead and zinc were significantly correlated with their total and extractable contents in soils. Iqbal and Shafiq (1999) have reported adverse effects of copper and zinc on seed germination and seedling growth of wheat. Lower level of copper in Karachi University campus soil than in industrial areas soils increased the growth of *A. lebbeck* plants.

The rubber factory soil reduced all the growth parameters relative to the control area soil (Table 2). Habib and Iqbal (1996) studied rubber factory effluents exhibited high magnitude of pollution. Many variables of *A. lebbeck* were reduced in the rubber factory soil due to decrease in water holding capacity, and organic matter and increased percentage of coarse sand, calcium carbonate, total soluble salts, available sulfate and chromium. Drought conditions appear as a consequence of the presence of high sand, low organic matter, loose soil structure, low irrigated water, high salinity and loose edaphic character. These characteristics were also observed in rubber factory soil which may cause reduction in the growth of *A. lebbeck*. Due to the colloidal nature of the organic matter the water holding capacity of soil was consequently increased in plant communities that had a higher percentage of soil organic matter (Sultani et al., 2007). These characters were observed in control area soil as compared with rubber factory soil. Iqbal and Rehman (2002) found that an increase in concentration of chromium suppressed the dry weight of *L. leucocephala*. Sen et al. (1994) reported that the uptake of Cr (VI) by the plant gradually increased with increase in concentration of Cr (VI) in the tannery effluents. The plants under stress conditions are most likely to be adversely affected by high level of heavy metals (Shafiq and Iqbal, 2005b). Chromium is a toxic metal for plant growth and its higher level in soil caused growth reduction in *A. lebbeck*.

A. lebbeck is a sensitive tree to grow in industrial area soil particularly in rubber factory soil. Maximum reduction in the growth of *A. lebbeck* was found in various soils of industrial areas of Landhi and Korangi as compared to other species in the vicinity of Karachi. Tolerant plants should be selected to grow in Landhi and Korangi 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

Table 1. Growth of *Albizia lebbeck* in soils of different areas

Treatments▲	Root length (cm)	Shoot length (cm)	Seedling length (cm)	No. of leaflets	Leaf area (sq cm)	Root dry weight (mg)	Shoot dry weight (mg)	Leaf dry weight (mg)	Total plant dry weight (mg)	Root/Shoot ratio	Leaf weight ratio	Specific leaf area ($cm^2 g^{-1}$)	Leaf area ratio ($cm^2 g^{-1}$)
A	8.30 a	11.25 a	19.55 a	169.00 a	43.66 a	80.00 a	47.50 a	120.00 a	247.50 a	1.76 a	0.48 a	359.29 a	173.83 ab
	±0.25	±0.71	±0.93	±20.15	±6.44	±5.77	±6.29	±8.16	±17.97	±0.21	±0.01	±33.98	±14.42
B	6.88 ab	9.78 a	16.65 ab	114.75 a	41.04 a	60.00 ab	45.00 a	87.50 ab	192.50 ab	1.40 a	0.61 a	558.08 a	230.71 a
	±0.66	±0.94	±0.33	±8.81	±3.52	±10.80	±5.00	±16.52	±25.29	±0.32	±0.13	±164.20	±46.13
C	6.93 ab	10.45 a	17.38 ab	122.75 a	41.11 a	45.00 bc	55.00 a	77.50 abc	177.50 ab	1.23 ab	0.46 a	668.39 a	227.36 a
	±0.41	±0.52	±0.86	±14.92	±7.79	±6.45	±25.33	±14.93	±14.93	±0.34	±0.11	±288.64	±27.76
D	6.43 ab	6.73 b	13.15 c	16.50 b	3.45 b	32.50 cd	40.00 a	42.50 bc	115.00 bc	1.07 ab	0.33 a	250.38 a	94.97 b
	±0.53	±1.00	±0.53	±7.93	±2.03	±4.78	±16.83	±17.97	±36.63	±0.23	±0.07	±114.59	±49.55
E	4.73 b	10.70 a	15.43 bc	117.75 a	32.94 a	17.50 d	30.00 a	30.00 c	77.50 c	0.42 b	0.37 a	473.77 a	237.21 a
	±1.18	±0.62	±1.74	±34.82	±15.56	±2.50	±12.25	±17.32	±28.69	±0.16	±0.14	±42.48	±55.04
L.S.D.	2.06	2.35	3.02	60.01	25.61	20.03	45.51	46.41	78.02	0.79	0.31	479.2	124.94

A = Karachi University soil; B = Towel factory soil; C = Garment factory soil; D = Rubber factory soil; E = Ply Board factory soil; ▲ 50% soil + 50% garden soil in all soil types; Statistical significance was determined by analysis of variance; numbers followed by the same letters in the same column are not significantly different, according to Duncan's Multiple Range Test. LSD = least significance difference, value at $p < 0.05$ level; ± Standard error

Table 2. Percentage reduction in growth of *Albizia lebbeck* in soils of different factories in comparison to the control soil

Treatments▲	Root length	Shoot length	Seedling length	Plant cover	No. of leaflets	Leaf area	Root dry weight	Shoot dry weight	Leaf dry weight	Total plantdry weight	Root/Shoot ratio	Leaf weight ratio	Specific leaf area	Leaf area ratio
A	17.1	13.1	14.8	40	32.1	6	25	5.3	27.1	22.2	20.5	27.1*	55.3*	32.7*
B	16.5	7.1	11.1	29.5	27.4	5.8	43.8	15.8*	35.4	28.3	30.1	4.2	86.0*	30.8*
C	22.5	40.2	32.7	68.4	90.2	92.1	59.4	15.8	64.6	53.5	39.2	31.3	30.3	45.4
D	43	4.9	21.1	51.2	30.3	24.6	78.1	36.8	75	68.7	76.1	22.9	31.9*	36.5*

A = Towel factory soil; B = Garment factory soil; C = Rubber factory soil; D = Ply board factory soil. Actual names of the factories were deliberately omitted to protect the privacy of the industry;
▲ Treatments consisting of 50% industrial soil + 50% garden soil; Percentage increase = *

Table 3. Soil characteristics of Karachi University and industrial areas soils

Sites	Coarse sand (%)	W.H.C. (%)	Organic matter (%)	$CaCO_3$ (%)	Total soluble salts (%)	pH	Available sulfate (μg g^{-1})	Cu (μg g^{-1})	Zn (μg g^{-1})	Cr (μg g^{-1})
A	58 b	27 b	2.0 b	17.8 c	5.9 c	8.4 a	8 d	0.002 c	0.029 bc	6.066 a
	±0	±0	±0.3	±0.3	±0.7	±0.0	±0	±0.002	±0.017	±0.046
B	24 d	29 b	2.1 b	29.5 b	14.0 a	8.0 ab	575 a	0.023 b	0.033 b	4.139 b
	±2	±3	±0.2	±1.5	±2.0	±0.1	±13	±0.012	±0.001	±0.093
C	47 c	31 b	0.9 c	24.5 b	8.0 c	8.3 a	108 c	0.008 bc	0.090 a	4.229 b
	±0	±2	±0.0	±0.5	±0.0	±0.1	±23	±0.002	±0.002	±0.111
D	88 a	17 c	1.1 c	36.5 a	12.0 ab	8.2 ab	401 b	0.002 c	0.019 bc	6.899 a
	±1	±3	±0.1	±2.5	±0.0	±0.1	±11	±0.002	±0.002	±0.978
E	26 d	40 a	3.3 a	17.5 c	9.0 bc	7.8 b	608 a	0.074 a	0.003 c	1.404 c
	±2	±0	±0.4	±1.5	±1.0	±0.2	±45	±0.002	±0.002	±0.406
L.S.D.	5	8	0.8	5.4	3.8	0.4	86	0.02	0.027	1.738

A = Karachi University soil; B = Towel factory soil; C = Garment factory soil; D = Rubber factory soil; E = Ply Board factory soil; W.H.C. = Water Holding Capacity; Statistical significance was determined by analysis of variance; numbers followed by the same letters in the same column are not significantly different, according to Duncan's Multiple Range Test. LSD = least significance difference, value at $p < 0.05$ level; ± Standard error

Table 4. Percentage change in physical properties and chemical composition of industrial soils as compared to control soil

Treatments	Coarse sand	Water holding capacity	Organic matter	$CaCO_3$	Total soluble salts	Available sulfate	Cu	Zn	Cr
A	58.6	7.4*	5.0*	65.7*	137.3*	7087.5*	1050.0*	13.8*	31.8
B	19.0	14.8*	55.0	37.6*	35.68	1250*	300.0*	210.3*	30.3
C	51.7*	37.0	45.0	105.1*	103.4*	4912.5*	0.0	34.5	13.7*
D	55.2	48.1*	65.0*	1.7	52.5*	7500.0*	36.00*	89.7	76.9

A = Towel factory soil; B = Garment factory soil; C = Rubber factory soil; D = Ply Board factory soil. Actual names of the factories were deliberately omitted to protect the privacy of the industry; Percentage increase = *

levels in soils of the industrial areas. Such information could also be useful for landscaping and urban planning.

References

Ashenden T.W., Mansfield T.A. (1977). Influence of wind speed on the sensitivity of rye grass to SO_2. J. Exp. Bot. 28: 729-735.

Bell J.N.B., Rutter A.J., Relton J. (1979). Studies on the effects of low levels of sulphur dioxide on the growth of *Lolium perenne* L. New Phytol. 83: 1-7.

Bower C.A., Wilcox L.V. (1965). Soluble salts. In: Methods of soil analysis, part 2. Black, C.A., Evans, D.D., Ensminger, L.E., White, J.L., Clark, F.E. (eds.). pp.933-951. American Society of Agronomy, Inc., Madison, Wisconsin.

Camplin, W.C. (2001). Effect of paper and pulp factory of Indonesia on the growth and yield potential of cereal crops. Environ. Pollution 33:324-331.

Clemente R., Walker D.J., Bernal, M.P. (2005). Uptake of heavy metals and As by *Brassica juncea* growen in a contaminated soil in Analcollar (Spain): The effect of soil amendments. Environ. Pollution 138: 46-58.

Dane J.H. (2002). Methods of soil analysis. SSSA Book Series. Soil Sci. Soc. Amer., Madison, WI.

Davies M.A., Linsey, E.F. (2001). Drastic impacts of polluted waters on the yield of wheat in Europe grown near to the industrial estates. Water, Air Soil Pollution 16: 14-23.

Duncan D.B. (1955). Multiple Range and Multiple F-Test. Biometrics 11: 1-42.

Gerad C.J., Sexton P., Shaw G. (1982). Physical factor influencing soil strength and root growth. Agron. J. 74: 875-879

Gren, J., Trett M. (2000). Depressive effects of industrial wastewaters on the soil fauna and cereal crops in Europe. Water, Air Soil Pollution 632-643.

Habib I., Iqbal M.Z. (1996). Irrigational impact of rubber factory effluent on elemental bioaccumulation and metabolite concentration in component parts of *Triticum aestivum* var. UP-262. Sci. Sindh 3: 59-71.

Herschbach C. (2003). Whole plant regulation of sulphur nutrition: influences of the environment. Plant Biology 5: 233-244.

Herschbach C., Mult S., Kreuzwieser J., Kopriva S. (2005). Influence of anoxia on whole plant sulphur nutrition of flooding-tolerant poplar (*Populus tremula x P. alba*). Plant, Cell and Environment, 28, 167-175.

Iqbal M.Z. (1988) Accumulation of sulfur in foliage of roadside plantation and soil in Karachi city. Ecology, 29, 1-5.

Iqbal M.Z., Khalid F. (1997). Effects of polluted soil extracts on germination and seedling growth of some species. Pakistan J. Environ. Stud. 6: 25-28.

Iqbal M.Z., Qadir S.A. (1973). Effects of industrial pollution on seed germination. Pakistan J. Bot. 5: 155-158.

Iqbal M.Z., Rehman S.A. (2002). Effects of Cd, Zn, Cr and Pb on seed germination and seedling growth of plants. Pakistan J. Environ. Sci. 1: 47-53.

Iqbal M.Z., Rehman S.A. (2005). Effects of heavy metals on seed germination and seedling growth of *Albizia lebbeck* (L.) Benth. Sci. Sindh 12: 1-6.

Iqbal M.Z., Shafiq M. (1999). Effects of copper and zinc on germination and growth of wheat. Pakistan J. Arid Agric. 2: 43-50.

Jehan, S., Iqbal, M.Z. (1992). Morphological and anatomical studies of leaves of different plants affected by motor vehicular exhaust. J. Islamic Acad. Sci. 5: 21-23.

Jackson M.L. (1958). Soil Chemical Analysis. 408. Englewood Cliffs, NJ: Prentice- Hall.

Kartal S., Elci L., Kilicel F. (1993). Investigation of soil pollution levels for zinc, copper, lead, nickel, cadmium and manganese around Cinkur plant in Kayseri. Fresenius Environ. Bull. 2: 614-619.

Kashem A., Singh B.R. (1999). Heavy metal contamination of soil and vegetation in the vicinity of industries in Bangladesh. Water, Air, Soil Pollution 115: 347-361.

Mahmood, T., Iqbal, M.Z. (1989). Impact of vehicular emission on seed germination of some road side trees. Pakistan J. Sci. Ind. Res. 32: 752-753.

Qadir N., Iqbal, M.Z. (1991). Growth of some plants raised from polluted and unpolluted seeds. Int. J. Environ. Stud. 39: 95-99

Qadir S.A., Qureshi S.Z., Ahmed M.A. (1966). A phytosociological survey of the Karachi University Campus. Vegetatio 13: 339-362.

Rehman S.A., Iqbal M.Z., Mumtaz M. (2007). Metal transfer ratio of *Leucaena leucocephala*: an experimental study using the soils of industrial areas of Korangi and Landhi, Karachi. J. Basic Appl. Sci. 3: 11-18.

Sen A.K., Mondal N.G., Paliawal K. (1994). Effect of tannery effluent on seed germination, leaf area, biomass and mineral content of some plants. Bioresource Technol. 47: 215-218.

Shafiq M., Iqbal M.Z. (2005-a). Tolerance of *Peltophorum pterocarpum* D. C. Baker Ex K. Heyne seedlings to lead and cadmium treatment. J. New Seeds 7: 83-94.

Shafiq M., Iqbal M.Z. (2005-b). The toxicity effects of heavy metals on germination and seedling growth of *Cassia siamea* Lamk. J. New Seeds 7: 95-105.

Steel R.G.D., Torrie, J.H. (1984). *Principles and Procedures of Statistics,* pp. 172-177, 2nd edition, Mc Graw Hill Book Co., Singapore.

Sultani M.I., Gill M.A., Anwar M.M., Athar M. (2007). Soil physical properties as influenced by various green manuring legumes and phosphorus fertilization under rainfed conditions. Int. J. Environ. Sci. Technol., 4:109-118.

Türkan, I. (1988). The effect of exhaust gas on seed germination and seedling growth of cucumber (*Cucumber sativus* L.) and wheat (*Triticum aestivum* L. subsp. *vulgare*). J. Turkish Phytopath. 17: 81-87.

Valee B.L., Ulmer D.D. (1990). Biochemical effect of mercury, cadmium and lead. Annu. Rev. Biochem. 41: 91-128.

Webb, R. (1998). Urban forestry in Kuala Lumpur, Malaysia. Arboriculture Journal. 22: 287-296.

WHO/UNEP, (1992). Urban Air Pollution in Megacities of the World. WHO, UNEP. Earthwatch, Blackswell, Oxford, UK.
Yasir, M. (2003). Wastewater and its effect on some crops. Water, Air, Soil Pollution 32-36.
Yruela Y. (2005). Copper in plants. Brazilian J. Plant Physiol. 17: 145-156.
Zaman Q.U., Iqbal M.Z. (1994). Vegetation pattern along the sewage effluents channels of Malir river (Karachi). Turkish J. Bot. 18: 425-430.

acs76_17