Pak. J. Bot., 42(1): 661-678, 2010.

VEGETATION PATTERN AND SOIL CHARACTERISTICS OF THE POLLUTED INDUSTRIAL AREA OF KARACHI

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Abstract

A quantitative phytosociological survey was conducted around the industrial areas of Sindh Industrial Trading Estate (S.I.T.E.) of Karachi. The herbaceous, shrubs vegetation was predominantly disturbed in nature. Fifteen plant communities based on Importance Value Index (IVI) of species were recognized. Eighty plant species were recorded in industrial areas. *Abutilon fruticosum* L., attained the highest importance value index (823.25) followed by *Prosopis juliflora* DC. (662.62), *Corchorus trilocularis* L. (467.20), *Aerva javanica* Burm.f. (419.97), *Amaranthus viridis* L. (397.65) and *Senna holosericea* L. (387.22), respectively. *P. juliflora* and *A. fruticosum* showed leading first dominant in five and four stands, respectively. Whereas, *A. javanica*, *A. viridis*, *S. holosericea*, *Launaea nudicaulis* L., *Crochorus depressus* L. and *Salvadora* L., attained the presence class III. *Zygophyllum simplex* L., *Suaeda fruticosa* L., *Convolvulus glomeratus* Choisky, *Cressa cretica* L., *Cleome viscosa* L., *Calotropis procera* Willd, *Blepharis sindica* T. Anderson, *Rhynchosia pulverulenta* L., *Abutilon pakistanicum* Jafri & Ali, *Chenopodium album* L., *Capparis decidua* Forssk and *Digera muricata* L. Mart showed the presence of class II. Whereas, rest of 58 species showed presence of class I.

The soil characteristics of the polluted industrial area were also analyzed and related with the vegetation of the polluted areas. The Industrial area soil was coarse in texture and ranged from sandy clay loam to sandy loam. The soil was acidic to alkaline in nature. Maximum water holding capacity, bulk density, porosity, $CaCO_3$, pH, organic matter, total organic carbon, chloride, electrical conductivity, total dissolved salt, available sulphur contents, exchangeable sodium and potassium were recorded in wide range. It was concluded that certain edaphic factors due to industrial activities and induction of pollutants were responsible for variation in vegetation composition of the study area.

Introduction

Problem of environmental pollution has existed since early time and is still growing rapidly as a result of unplanned industrialization, particularly in developing countries (Naheed *et al*., 1986).The hazard and fast industrial growth is causing an enormous environmental pollution problems and affecting distribution of plants and soil characteristics of the area. Industrial pollution is caused by the discharges of varieties of industrial pollutants in the forms 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 & Endenijk, 1987). The phytosociological studies around industrial areas of Karachi had been carried out by few workers (Chaudhry, 1961; Qadir *et al*., 1966; Iqbal & Qadir, 1974; Ahmed *et al*., 1978; Shafiq *et al*., 1992; Iqbal & Shafiq, 1996; Iqbal *et al*., 2001). High intense disturbances sometimes threaten the survival of some species and yield to low richness (Barbara, 2003). As acid rain kill trees, destroy the leaves of plants, can infiltrate soil by making it unsuitable for purposes of nutrition and habitation. Similarly in air pollution, ozone in the

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lower atmosphere can prevent plant respiration by blocking stomata and negatively affecting plants photosynthesis rates which will stunt plant growth; ozone can also decay plant cells directly by entering stomata. Due to polluted water terrestrial and aquatic plants may absorb pollutants from water (as their main nutrients source) and pass them up the food chain to consumer animals and humans. Similarly plants may absorb soil contaminates and pass them up the food chain. Various kinds of industrial pollutants affecting the plants have been reported by Habib & Iqbal, 1996; Iqbal & Khalid, 1997. Along the sewage effluents channels of Malir River, Karachi, heavy metals polluted soil influenced on the composition of growing plant communities in this area (Zaman & Iqbal, 1994). Some plant species have the ability to survive and reproduce on soil containing high concentration of metals in forms that are toxic or inimical to other plants (Uzair *et al*., 2009). The ability of these plants to survive on metals polluted soils is not only due to their capacity to take up, translocate and sequester metals, but is also based on mechanisms that allow them to tolerate high levels of the element in root and shoot cells by alleviating their toxic effects.

The city of Karachi is located on semi arid zone at 64^{o} longitude and 27^{o} latitude on the shores of the Arabian Sea with moderate climate. May and June are hottest months of the year with temperature as high as 43^{o}C while January is the coldest month with temperature as low as 5^{o}C. Rain in Karachi is seasonal, averaging less than 22 cm per year between June and September and rare for the rest of the year. Occasionally, there are dry year too while strong coastal winds and better dew formation are the characteristics feature of Karachi (Iqbal & Shafiq, 1996).

Karachi is the 22nd largest city of the world and the biggest city of Pakistan. The ever growing high rates of population growth and industrial units in the city of Karachi is observed as compared to other cities of the country. It is the hub of the industrial and commercial activities of the country. Karachi has five main industrial estates like, Sindh Industrial Trading Estate (S.I.T.E.), Korangi Industrial Trading Estate (K.I.T.E.), North Karachi Industrial Trading Estate (N.I.T.E.), Landhi Industrial Trading Estate (L.I.T.E.) and Hub Industrial Trading Estate (H.I.T.E.). Industrial activities discharge several types of pollutant in the environment which are polluting the air, water and soil of the area.

The study area of Sindh Industrial Trading Estate (S.I.T.E.) is a densely populated town in western part of Karachi, Pakistan. This site is bordered by Gadap Town to the North, Liaquatabad and North Nazimabad to the east across the Orangi stream, Layari and Saddar to the South across the Layari River and Kemari to the West. It is the oldest and the largest designated industrial area of Pakistan, encompassing 19 km^2 area and contains of approximately 2516 industries which are considered responsible for environment degradation. These different types of industries including garments, bones crushing, coloring, metal processing, pharmaceutical, textile, chemicals and battery manufacturing industries are present in the S.I.T.E. areas. These industries discharge different kinds of waste effluents and solid wastes which are polluting the soil of nearby places, thus causing deleterious effects to plant communities of the industrial areas. So vegetation of study area was found very disturbed due to constructions of new industries day by day. As during the establishment of new industries natural vegetation is destroyed on large scale if few species survive in such area they are threatened by different types of pollutants discharged from industries.

In order to evaluate the destruction of vegetation caused by industries, the aim and objective of the present study was to investigate the edaphic characteristics of the polluted industrial areas exploring the vegetation characteristics of the area.

Materials and Methods

A Phytosociological survey was conducted in S.I.T.E. industrial areas during mid November to early December, 2006 by Point Centered Quarter (PCQ) method of Cottom & Curtis (1956). Thirty stands were studied in the industrial areas. Relative density, Relative frequency and Relative cover were calculated and Importance Value Index (IVI) was obtained by the addition of these community attributes. The community was named according to first dominated species (attained highest IVI in stand). In our study equal spaced sample points were positioned through the study area. Each sample point was then divided into quarters and, in each, the distance, cover and species name of the individual closest to the samples points were recorded.

Soil samples were obtained from industrial areas of every stand at 45 cm depth. These samples were brought to the laboratory in polythene bags and were kept in air for drying. The soil samples were passed through 2 mm sieve after drying was subjected to physical and chemical analysis. Mechanical analysis of soil samples were carried out by Bouyoucos (1962) hydrometer method, maximum water holding capacity (M.W.H.C.) of soil was calculated by the method of Keen (1931). Bulk density of soil was found according to Birkeland (1984). Calcium carbonate was determined by a method of acid neutralization, as described by Qadir *et al.*, (1966). Soil pH was determined by direct pH reading meter (Mettler Toledo, MP 220). Chlorides were evaluated through titration by Mohr's Method (Allen *et al.*, 1974). Estimation of Organic matter was done according to Jackson (1958). Organic matter was converted into total organic carbon by using the conversion factor 1.724 (organic matter/ 1.724 = g organic carbon) as given by Nelson & Sommers (1996). Soil available sulphur was determined by the turbidity method as described by Iqbal (1988). Exchangeable sodium and potassium in soil was determined according to Richards (1954). Soil Electrical Conductivity (E.C.) and Total Dissolved Salt (TDS) were determined by AGB 1000 (England) conductivity reading meter.

Results

A field survey for edaphic characteristics and status of plants growing around the largest industrial sites are conducted in Karachi, Pakistan. Phytosociological characteristics of study area was described in Table 1. The most widely distributed plant species are summarized in Table 2. Different plant communities and their soil characteristics are shown in Table 3 while Table 4 and 5 showed the physical and chemical soil analysis of the study area. *Abutilon fruticosum* L., attained the highest importance value index (823.25) followed by *Prosopis juliflora* DC. (662.62), *Corchorus trilocularis* L., (467.20), *Aerva javanica* Burm.f. (419.97), *Amaranthus viridis* L., (397.65), *Senna holosericea* L., (387.22), *Tribulus terrestris* L., (360.83), *Launaea nudicaulis* L., (328.49), *Zygophyllum simplex* L., (321.02), *Suaeda fruticosa* L., (313.86) and *Convolvulus glomeratus* Choisky (313.08) respectively. Whereas, *Crochororus depressus* L., attained moderate Importance value indices (266.58) followed by *Cressa crectica* L., (263.51), *Cleome viscose* L., (245.14) and *Calotropis procera* Willd (228.73) respectively. *Fagonia indica* L., attained better Importance value indices (191.16) followed by *Chloris barbata* L., (163.48), *Mollugo lotoides* L., (144.21), *Salvadora sp.*, (133.79), *Blepharis sindica* T. Anderson (119.08), *Solanum albicaule* Kootschy and *Digera muricata* (L.,) Mart (113.02), respectively. Fifty eight species showed less than 82 Importance value index.

A. fruticosum showed its leading presence class V. *P. juliflora, C. trilocularis* and *T. terrestris* attained the presence class IV. *A. javanica, A. viridis, S. holosericea, L. nudicaulis, C. depressus* and *Salvadora* sp., had the constancy class III. Whereas, *Z. simplex, S. fruticosa, C. glomeratus, C. cretica, C. viscosa, C. procera, B. sindica, D. muricata, C. decidua, A. pakistanicum* and *R. pulverulenta* showed the presence class II. Whereas, species showed the lowest presence class I. *P. juliflora, A. fruticosum, C. trilocularis, A. javanica, A. viridis* and *C. viscoasa* occurred as first leading dominant in association with second and third dominant species.

There are 24 species viz., *P. jailor, A. fruticosum, C. trichorus, A. javanica, A. viridis, S. holosericea, Z. simplex, S. fruticosa, C. depressus, C. cretica, C. viscose, C. procera, F. indica, C. barbata, T. terrestriss, L. nudicaulis, B. sindica, Salvadora sp., S. albicaule, C. decidua, A. sessilis, A. pakistanicum, H. recurvum* and *M. lotoides* which occurred as first, second or third leading dominant species in studied areas.

The community descriptions in relation to soil characteristics influenced by the industrial activities are described as follows:

1. *Prosopis juliflora* community: *P. juliflora* is considered as aggressive and tolerant species. In industrial area it occurred in 21 stands out of 30 stands and leads its dominance in 5 stands. This community preferred to grow on high percentage of sand (61.36%), silt (13.64%) and clay particles (24.97%). The community preferred sandy clay loam type soil. Better water holding capacity of soil (25.36%), bulk density (1.47 g^{-cc}), porosity (43.70%), Calcium carbonate (14.68%), pH (7.26), chloride (311 mg^{-L}), organic matter (3.48%), total organic carbon (2.18 g) were recorded here with lowest available sulfur contents (80.62 μg^{-g}), moderate electrical conductivity (7.15 dS^{-cm}), total dissolved salt (5.30 mg^{-L}), exchangeable sodium (442 ppm) and potassium (185 ppm).

2. *Abutilon fruticosum* community: *A. fruticosum* occurred in 25 stands out of 30 stands and leads its first dominance position in four stands. It was recorded in moderate percentage of sand (52.46%), silt (23.00%) and clay (24.54%), respectively. This community preferred to grow on sandy clay loam type soil which had moderate water holding capacity (26.26%), bulk density (1.43 g^{-cc}), porosity (46.88), $CaCO_3$ (18.61%), pH (7.15), chlorides (188.8 mg^{-L}) and total organic carbon (2.13 g). While low amount of organic matter (3.95%), available sulfur contents (96.57 μg^{-g}), exchangeable sodium (153 ppm) and potassium (136 ppm), electrical conductivity (6.2 dS^{-cm}) and total dissolved salt (3.15 mg^{-L}) were found in industrial areas soil in which this community was flourishing.

3. *Zygophyllum simplex* community: *Z. simplex* occurred in 10 stands in study area while in 3 stands it occurs as a first leading dominant species. Community is supported by higher percentage of total sand (50.06%) with low amount of silt (18.07%) and highest percentage of clay particles (31.86%). This community preferred sandy clay loam. Water holding capacity of soil of this community was slightly high (28.15%) with high exchangeable sodium (604 ppm), moderate exchangeable potassium (156 ppm), bulk density (1.43 g^{-cc}) and porosity (46.00%). The soil samples of the community contained lowest $CaCO_3$ (7.15%), with acidic pH (6.91), chloride (360 mg^{-L}), organic matter (3.20%) total organic carbon (1.85 g), available sulfur (106.25 μg^{-g}), electrical conductivity (9.0 dS^{-cm}) and total dissolved salt (6.70 mg^{-L}).

4. *Aerva javanica* community: This community occurs in 15 stands while dominating in 4 stands. It community is supported by high percentage of total sand (57.30%) with more or less equal amount of silt (21.83%) and clay particles (20.78%), preferred to grow on sandy clay loam. Water holding capacity of soil of this community was slightly high (27.30%) with total organic carbon (2.77 g). Soil bulk density and porosity were 1.40 g^{-cc} and 46.75%, respectively. The soil of this community contained low $CaCO_3$ (16.68%), pH (7.18), chloride (195 mg^{-L}), organic matter (4.37%), available sulfur (86.30 μg^{-g}), exchangeable sodium (83 ppm) and potassium (88 ppm), electrical conductivity (2.15 dS^{-cm}) and total dissolved salt (1.65 mg^{-L}).

5. *Corchorus trilocularis* community: It is recorded in 20 stands in which 2 stands it occurred as leading dominant. This community had better percentage of sand (56.80) and silt (16.00%) with 27.10% clay. This community preferred to grow on sandy clay loam. Water holding capacity of soil of this community was slightly high (25.10%) with moderate exchangeable potassium (198ppm). Soil bulk density and porosity were 1.49g^{-cc} and 43.80%, respectively. The polluted soil of industrial sites contained low $CaCO_3$ (19.30%), pH (7.25), chloride (130 mg^{-L}), organic matter (3.15%), total organic carbon (1.83 g), available sulfur (86.30 μg^{-g}), exchangeable Sodium (98ppm), electrical conductivity (1.4 dS^{-cm}) and total dissolved salt (1.10 mg^{-L}).

6. *Suaeda fruticosa* community: This community occurs in 8 stands while dominating in 2 stands. Soil characteristics with relation to *S. fruticosa* plant community indicated that this community is well growing in the industrial area polluted soil sandy clay loam, with high percentage sand (48.30%) and low silt (28.68%) and high clay (22.97%). Maximum water holding capacity was found high (24.91%) with high total organic carbon (3.37 g) and exchangeable sodium (1320 ppm) in polluted soil of this community. Low bulk density (1.37g^{-cc}) and porosity (48.37%) were found in this community. Low calcium carbonate (11.75%), soil pH (6.49) and chloride (mg^{-L}) were recorded in the soil. Moderate percentage of organic matter (5.85), and exchangeable potassium (108 ppm), low available sulfur contents (104.35 μg^{-g}), high electrical conductivity (25.85 dS^{-cm}) and total dissolved salt (19.05 mg^{-L}) were determined in this community.

7. *Cressa cretica* community: This community occurs in 8 stands while dominating in 2 stands. Soil characteristics indicated that this community is well growing in industrial area polluted soil with high percentage of sand (41.12%), as compared to silt (32.43%) and clay (26.45%). This community preferred to grow on sandy clay loam. Maximum water holding capacity (28.96 %), bulk density (1.35 g^{-cc}), porosity (48.75%), $CaCO_3$ (22.22%), exchangeable potassium (96 ppm) and pH (7.2) were recorded in soil of this community. These soil also contained 60.00 mg^{-L} chloride with high organic matter (5.70%), total organic carbon (3.30 g), available sulfur (85.65 μg^{-g}), exchangeable sodium (252 ppm), electrical conductivity (17.05 dS^{-cm}) and total dissolved salt (12.55 mg^{-L}).

8. *Amaranthus viridis* community: Sandy clay loam soils showed 57.30% sand, 15.50% silt and 27.2% clay with maximum water holding capacity, bulk density and porosity were 26.45%, 1.43 g^{-cc} and 46.00%, respectively with soil pH 6.84. Some other soil characteristics such as chlorides (425.00 mg^{-L}), organic matter (5.47%) total organic carbon (3.18 g), available sulfur (44.37 μg^{-g}), exchangeable sodium (340 ppm) and potassium (300 ppm), were quite high with moderate electrical conductivity (7.20 dS^{-cm}) and total dissolved salt (5.35 mg^{-L}).

9. *Fagonia indica* community: This species was found in sandy loam with moderate percentage of sand (52.37%), silt (22.75%) and clay (24.88%) in industrial soil samples. Maximum water holding capacity (25.01%), bulk density (1.48 g^{-cc}), porosity (44.25%), $CaCO_3$ (15.37%) and pH (6.94) were recorded. Some other soil characteristics such as chlorides (252.50 mg^{-L}), organic matter (3.35%), total organic carbon (1.95 g), available sulfur (52.50 μg^{-g}), exchangeable sodium (366 ppm) and potassium (156 ppm), electrical conductivity (4.40 dS^{-cm}) and total dissolved salt (3.25 mg^{-L}) were also recorded in this community.

10. *Senna holosericea* community: Total percentage of sand, silt and clay was 61.80%, 13.56% and 25.20%, sandy clay loam respectively in *S. holosericea* community. Maximum water holding capacity, bulk density and porosity were 27.23%, 1.45 g^{-cc} and 45.50%, respectively. Some other soil characteristics such as soil pH 7.31, chlorides (245.00 mg^{-L}), organic matter (3.35%), total organic carbon (1.94), available sulfur (55.00 μg^{-g}), exchangeable sodium (200 ppm) and potassium (200 ppm), were quite high with low electrical conductivity (3.20 dS^{-cm}) and total dissolved salt (2.40 mg^{-L}).

11. *Corchorus depressus* community: This community showed its distribution in sandy clay loam with high percentage of sand (69.44%), low silt (11.00%) and clay (19.56%) particles. Low water holding capacity (23.91), bulk density (1.54 g^{-cc}) and high porosity (42.05%) were found in this community. High calcium carbonate (19.55%) and organic matter (3.55%), total organic carbon (2.06 g) were recoded. Alkaline soil pH (7.65) moderate chloride (140.00 mg^{-L}), exchangeable sodium (120 ppm) and potassium (80 ppm) were recorded in the community. High available sulfur contents (125 μg^{-g}) were determined for this community with very low electrical conductivity (0.80 dS^{-cm}) and total dissolved salt (0.60 mg^{-L}).

12. *Cleome viscosa* community: Total percentage of sand, silt and clay for this community was 48.30%, 29.00% and 22.70%, sandy clay loam respectively. Maximum water holding capacity (26.71%), bulk density (1.42 g^{-cc}) and porosity (46.50%) were recorded. Soil pH (7.64), calcium carbonate (15.30%), organic matter (5.25%), total organic carbon (2.47 g), chlorides (125.00 mg^{-L}), available sulfur (122.50 μg^{-g}), exchangeable potassium (144 ppm) were found high with very low electrical conductivity (0.90 dS^{-cm}), exchangeable sodium (76 ppm) and total dissolved salt (0.70 mg^{-L}) in soil of studied areas.

13. *Calotropis procera community*: This species showed its distribution in sandy loam type soil. High percentage of sand (59.80%), low silt (13.00%) and clay (27.20%) were recorded. This community had high maximum water holding capacity (26.15%), bulk density (1.45 g^{-cc}), porosity (45.00%), $CaCO_3$ (18.10%), pH (7.50) and exchangeable potassium (262 ppm). The other important soil characteristics such as low chlorides (145.00 mg^{-L}) and organic matter (2.00%), moderate available sulfur (118.75 μg^{-g}) and total organic carbon (1.61 g) were also recorded with low electrical conductivity (1.20 dS^{-cm}), total dissolved salt (0.90 mg^{-L}) and exchangeable sodium (54 ppm).

14. *Mollugo lotoides* community: This species preferred to grow in sandy clay loam type soil. High percentage of sand (54.80%), and low silt (21.50%) and clay (23.70%) were found in the soil of *M. lotoides* community. This community had high maximum water holding capacity (31.59%), bulk density (1.27 g^{-cc}), porosity (51.50%), $CaCO_3$ (18.40%) and exchangeable potassium (258 ppm). The other important soil characteristics such as acidic soil pH (6.82), high chlorides (315.00 mg^{-L}), organic matter (4.05%), total organic carbon (2.35 g), moderate available sulfur (36.25 μg^{-g}), exchangeable sodium (280 ppm), electrical conductivity (4.90 dS^{-cm}) and total dissolved salt (3.60 mg^{-L}) were recorded in soil of this community.

15. *Chloris barbata* community: This species occurred in five stands in which appeared first leading dominant in one stand. It is supported by higher percentage of total sand (64.80%) with low silt (13.00%) and high clay (22.20%) particles. This community preferred to grow on sandy clay loam. Water holding capacity in soil of the community was slightly high (33.36%). Low bulk density (1.33 g^{-cc}), porosity (27.00%), $CaCO_3$ (19.50%), exchangeable potassium (36 ppm) with moderate exchangeable sodium (240 ppm) were found in soil of this community. The soil contained alkaline pH (7.11), high chloride (445 mg^{-L}), organic matter (6.40%) total organic carbon (3.71 g), available sulfur (120.00 μg^{-g}) with 4.50 dS^{-cm} electrical conductivity and 3.30 mg^{-L} total dissolved salt.

Discussion

Plant communities around the industrial sites were composed on diverse type of plant species. The vegetation is predominately composed of halophytes, xerophytes and disturbed species. The vegetation was mostly dominated by *P. juliflora, A. fruticosum, A. javanica, S. fruticosa, F. indica, S. holosericea and C. procera* as leading dominant in the study areas. *A. javanica* in association with other disturbed species formed a prominent community, similar to the communities which were found around the cement factories of Karachi (Iqbal *et al.*, 2001). An appreciable amount of calcium carbonate, poor amount of organic matter is a characteristics feature of arid zone soils (Aubert, 1960). Plants directly depend on soil characteristics and climatic factors for their growth and development. Singh (1986) observed that in those plant communities 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). Industrial soils contained appreciable water holding capacity due to porosity of soil as soil pores can attain more water. Chloride and sulphur contents were also found more in industrial soil as compared to non-industrial soil which caused reduction in various growth variables in industrial soils. High amount of available sulfate reduces the plant growth and absorbed sulphur in the form of sulphate which might be due to industrial emission of SO_2. Exposure to SO_2 caused notable and significant reduction in the dry matter accumulation and yield of *Lolium perenne* L. cv. S23 (Ashenden & Mansfield, 1977; Bell *et al.*, 1979). Chemical balance of inorganic elements in the living organism is a basic condition for their proper growth and development (Markert, 1990). The plants under stress conditions are most likely to be adversely affected by high level of heavy metals. Excessive amount of heavy metals usually caused reduction in plant growth (Prodgers & Inskeep, 1981). Further more, morphology of bean plants was also influenced by the presence of metals; the color of plants was shown to turn yellow, which in turn affected photosynthesis (Azmat *et al*., 2005). The effects of toxic substances on plants are dependent on the amount of toxic substance taken up from a given environment. The toxicity of some metals may be so high that plant growth is retarded before large quantities of an element can be translocated (Haghiri, 1973). Based on low plant biodiversity in polluted areas, plant communities viz., *P. juliflora, A. fruticosum, A. javanica, S. fruticosa, F. indica, S. holosericea and C. procera* indicating their wide range of ecological adaptation. Soil type with respect to total percentage of sand, silt and clay is a key factor for distributions of plant communities. The vegetation of Sindh Industrial Trading Estates of Karachi was mostly halophytic and disturbed which is indicated by the community of *S. fruticosa* and *C. cretica*. Soil analysis indicated that industrial soil was sandy in nature with low percentage of organic matter while bulk density of industrial area soil was high with less porosity and maximum water holding capacity. Calcium carbonate was high in industrial soil while pH ranges from acidic to basis with high chlorides.

Phytosociologial and soil studies helps us in understanding the formation of plant communities. Such relationships are important because generally, when we relate each other to underlying factors a better picture of the relationships results. The challenges to save plant communities from the industrial disturbance are not new. The distribution of vegetation more closely resemble to the changes in the soil characteristics. Disturbance in the habitat types of the flora of the region makes it unproductive and produced negative impact on the ecosystem. Analysis of industrial area soil and vegetation showed variation due to discharge of various types of pollutants. The retention and presence of these pollutants in and surrounding the industries greatly decrease the habitat potential for flora of the region. The efforts and contribution from commercial, industrial and institutional sectors for the support of the flora located in and around these industrial units has the fruitful potential. It is concluded that industrialization activities strongly influenced the plant communities. Numbers of species in some plant communities had increased while in others were unable to survive Uzair *et al*., (2009) concluded the same findings at Dhabaji industrial area. Managing the stable environment for habitat of such plant species requires a diverse set of goals. One strategy would be to follow the selection of the plant species from the phytosociological studies that are known to having better importance value indices. Plantation in such disturbed areas is often helpful in removing the hazards materials from the environment. Concern about all flora of the region such as grasses, herbs and shrubs in the industrial areas needs proper attention. Eight communities preferred to grow on sandy loam type's soil. Whereas, 22 communities occurred on sandy clay loam soil. The soils of the industrial area were contaminated by pollutants. Heavy metal uptake has been found to have detrimental effects on plant growth or fitness (Giblin *et al*., 1980; Suntonvongsagul *et al*., 2007). Several scientists noted the capacity of salt marshes plants to take and absorb some quantity of heavy metals as *P. australis* could take up and store a variety of metals as a phytoremediator of Hg, Mg, and Cr contamination (Williams *et al*., 1994; Windham *et al*., 2001).

There is a need to developed green spaces within and around the industrial areas for the formation of better environmental conditions. To overcome the hazardous effects of toxic pollutants released from the industries in future our first priority must be a maintaining a healthy environment. An attempt has been made to focus on soil characteristics of the polluted areas and plant communities growing in that area. The conclusion which could be drawn from this study is that all the vegetation types which were observed around SITE area of Karachi were disturbed by human activities, mainly through the release of pollutants from different industries. If the haphazard population growth and the construction of new industrial structure go on then probably there would be more vegetation changes in near future.

References

Ahmed, M., S.A. Qadir and S.S. Shoukat. 1978. Multivariate approaches to the analysis of vegetational environmental complex of Gharo, Dhabeji and Manghopir industrial areas. *Pakistan Journal of Botany*, 10: 31-51.

Allen, S.E., M.H. Grimshaw, J.A. Parkinson and C. Quarmby. 1974. Chemical Analysis of Ecological Materials. In:(Ed.): S.E. Allen. Blackwell Scientific Publications, Oxford London, Edinburg, Melbourne, pp. 386.

Ashenden, T.W. and T.A. Mansfield. 1977. Influence of wind speed on the sensitivity of rye grass to SO_2. *Journal of Experimental Botany*, 28: 729-735.

Aslam, M., I.A. Mahmood, T. Sultan and S. Ahmed. 2000. Inoculation approach to legume crops and their production assessment in Pakistan. A Review. *Pakistan Journal of Biological Sciences*, 32: 193-195.

Aubert, L. 1960. *Arid Zone soils, Study of Their Formation Characteristics, Utilization and Conservation, in the problems of the Arid Zone*. UNESCO Publications, Paris. 115-137.

Azmat, R., F. Naz, T. Khanum and A. Hayat. 2005. Persistent of pathogen in heavy metals contaminated environment. *Pakistan Journal of Biological Sciences*, 8(2): 235-238.

Barbara, S., K. Kathrin and P. Jorg. 2003. Alternate management on fens: Responses of vegetation to grazing and mowing. *Applied Vegetation Science*, 6: 245-254.

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

Bhatti, M.A.R. 1999. Self sufficiency in food through soil improvement use of bio-fertilizers. *Pakistan Food and Agriculture Review*, 5: 12-14.

Birkeland, P.W. 1984. *Bulk Density Determination. Soil and Geomorphology*: Oxford University Press, New York,.14-15.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis. *Journal of Agronomy*, 53: 464.

Chaudhary, I.I. 1961. The vegetation of Karachi. *Vegetatio*, 10: 229-246.

Cottom, G. and J.T. Curtis. 1956. The use of distance measure in phytosociological sampling. *Ecology*, 37(3): 451-460.

Dueck, T.A. and G.J. Endenijk. 1987. Soil pollution and changes in vegetation. *Chamosphere*, 16: 1021-1030.

Giblin, A.E., A. Bourg, I. Valiela, and J.M. Teal. 1980. Uptake and losses of heavy metals in sewage sludge by a New England salt marsh. *American Journal of Botany*, 67: 1059-1068.

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

Haghiri, F. 1973. Cadmium uptake by plants. *Journal of Environmental Quality*, 2: 93-96.

Iqbal, M.Z. and F. Khalid. 1997. Effects of polluted soil extracts on germination and seedling growth of some tree species. *Polish Journal of Environmental studies*, 6: 25-28.

Iqbal, M.Z. and M. Shafiq. 1996. Plant communities on the sandy areas of Karachi University Campus. *Journal of Islamic Academy of Sciences*, 9(3): 89-98.

Iqbal, M.Z. and S.A. Qadir. 1974. Observations on the plant communities of polluted industrial drainage channels of Karachi, Pakistan. *Environmental Pollution*, 7: 253-257.

Iqbal, M.Z., M. Shafiq and S. Saeeda. 2001. Effects of cement dust on the growth of *Albizia lebbeck* and *Dodonaea viscose*. *Ecological Society* (ECOS), 478-482.

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

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

Keen, B.A. 1931. *The Physical Properties of Soil*. New York: Longman Greenand Company, pp.380.

Ladha, J.K., M.G. Kandu, A. Coppenolle, M.B. Peoples and P.J. Dart. 1996. Legume productivity and soil nitrogen dynamics in lowland rice based cropping systems. *Soil Science Society of America Journa*l, 60: 183-192.

Markert, B. 1990. *Elements concentrations cadasters in Ecosystem*. VCH, Federal Republic of Germany, pp. 448.

Nelson, D.W. and L.E. Sommers. 1996. Total carbon, organic carbon and organic matter. In: *Methods of soil analysis*, part 2, 2nd (Ed.): A.L. Page *et al*., Agronomy. 9:961-1010. American Society of Agronomy. Incorporation Madison, WI.

Naheed, S., N. Ariz and S. Baig. 1986. Studies of particulate air pollutants in the vicinity of a cement factory and its health hazards. *Pakistan Journal of Scientific and Industrial Research*, 29(4): 95-102.

Prodgers, R.A. and W.P. Inskeep. 1981. Heavy metal tolerance of inland salt grass Distichlis spicata. *Great Basin Naturalist*, 51: 271-278.

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

Richard, L.A. 1954. *United States Lab. Staff Agricultural Handbook* No. 60, United State Department of Agriculture, pp. 129.

Shafiq, M., M.Z. Iqbal and I. Habib. 1992. Phytosociological studies around the industrial areas of Landhi, Karachi, Pakistan. *New Agriculturist*, 3: 179-188.

Singh, A.P. 1986. Seasonal fluctuation of organic matter with relation to moisture retention characteristics and availability of water in salt effected soil (India*) Acta Botanica Indica*, 14: 73-76.

Suntornvongsagul, K., D.J. Burke, E.P. Hamerlynck and D. Hahn. 2007. Fate and effects of heavy metals in salt marsh sediments. *Environmental Pollution*, 149: 79-91.

Uzair, M., M. Ahmed and K. Nazim. 2009. Effect of industrial waste on seed bank and growth of wild plant in Dhabeji area, *Pakistan Journal of Botany*, 41(4): 1659-1665.

William, T.P, J.M. Bubb and J.N. Lester. 1994. Metal accumulation within salt marsh environments: A review. *Marine Pollution Bulletin*, 28: 277-290.

Windham, L., J.S. Weis and P. Weis. 2001. Patterns and processes of mercury release from leaves of two dominant salt marsh macrophytes, *Phragmites australis* and *Spartina alterniflora*. *Estuaries*, 24: 787-795.

Zaman, Q.U. and M.Z. Iqbal. 1994. Vegetation pattern along the sewage effluents channels of Malir river (Karachi). *Turkish Journal of Botany*, 18: 425-430.

Zia, M.S., M.B. Baig and M.B. Tahir. 1998. Soil environment issues and their impact on agricultural productivity of high potential area of Pakistan. *Science Vision*, 4: 56-61.

(Received for publication 16 September 2009)