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Seasonal variations in some soil characteristics on urban area of Karachi, Pakistan

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A comparative study on seasonal variations in some soil characteristics on urban area of Karachi was carried out. Seasonal variation disturbances due to environmental factors in edaphic characteristic may cause differences in mineral nutrients status. Therefore, it is necessary to study the seasonal variations in soil characteristics the urban area. The chemical characteristics of the urban area soil viz. A=Karachi University, B=Manghopir, C=Patel Para, D=Cantt area, E= N.I.T.E. (New Karachi Industrial Trading Estate, Godhra Industrial Area New Karachi), F= K.I.T.E. (Korangi Industrial Trading Estate), G= S.I.T.E. (Sindh Industrial Trading Estate) showed slight variation in autumn and winter season. The soil of the urban areas was alkaline in nature and contained an appreciable amount of calcium carbonate. The soil of the urban areas showed significant $p<0.05$ difference in calcium carbonate, sodium and potassium in autumn season. The soil pH of all the seven different sites was found differently in autumn and winter season, respectively. Chemical properties of soil in terms of calcium carbonate at all sites were non-significantly different in winter season. However, the concentration of soil extractable sodium and extractable potassium were found significantly different among all the sites

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Keywords: Calcium carbonate, industrial areas, potassium, pH, season, soil characteristics, sodium, urban soil

INTRODUCTION

Soil is the collection of natural bodies on the earth's surface, in places modified or even made by man of earthy materials, containing living matter and supporting or capable of supporting plants out of doors. Soil includes the horizons near the surface that differ from the underlying rock material as a result of interactions, through time, of climate, living organisms, parent materials, and relief (S.S.S.F.1975) and is an important component of the earth's biosphere (Glanz, 1995). Soil is an amazing, mostly natural material that covers nearly all of the land surface of the earth and soil, along with water and air, provides the basis for human existence. It is the interface between the earth's atmosphere and bedrock or ground water. It has either formed in place or has been transported to its present location by wind, water, ice, gravity, or humans. Soils may have been deposited thousands or millions of years ago by volcanoes, glaciers, floods, or other processes or were delivered to the site by truck or other mechanical device an hour ago, a week ago, or several months ago (Schreyer and Hipple, 2005). Below ground soil characteristics are recognized as possible key factors in affecting plant species coexistence and community organization (Bonanomi and Mazzoleni, 2005). Modifications associated with urban infrastructure directly impact soil properties.

In particular, soil bulk density, microbial biomass and activity, and organic matter are impacted by anthropogenic activities (Scharenbroch et al., 2005). Monitoring the environmental impact of anthropogenic disturbance on soil ecosystem is of great importance for optimizing strategies for soil use, conservation and remediation and find out the possibilities of long term human induced disturbance can affect main chemical and biological properties in an agricultural soil (Gelsomino et al., 2006). Soils, as composed of mineral constituents, organic matter (humus), living organisms, air and water, are of vital importance to the human health and well being. In today's urban area, soils have been disturbed severely (Shi et al., 2008). Urban soils have long presented a challenge to the soil scientist. Many heavily urbanized sites have been repeatedly excavated, admixed, cut, filled, and graded over to the point where they look like dirt and debris mixed up in a blender and pressed with a giant trash compactor. When there's seemingly no rhyme or reason to a site, the soils can be difficult to map and their study may call for some unconventional approaches (S.S.S.A., 2012). The effects of different land use patterns on soil microbial properties and soil quality are studied. In a study the soil nutrient status, microbial biomass nitrogen and enzyme activities under five different land use patterns—nature forest, park, farmland, street green, and roadside tree sites at various soil depths in Beijing, China observed. The results showed that soil properties were significantly affected by urban land use patterns and soil depths in the urban environment (Zaho et al., 2012). The chemical composition of soil and appropriate supply of nutrients are very important factors for normal plant growth and development. In an investigation it was observed that the total element concentrations in urban soils did not exceed values commonly found in urban environments. Higher concentrations of Na, Cl, Ca, Mg, Zn, Cu, and increased pH, but lower P and B concentrations were found in the street soils in comparison to the park soil of Riga (Latvia). Significantly higher concentrations of Na, Cl, and Mg, and lower concentrations of K, Fe, Cu, and B, as well as unfavorable ratios of several element concentrations were found in the soils where more damaged street trees were growing (Cekstere and Osvalde, 2013).

The aim of the present study was to investigate the seasonal variations of Na^+, K^+, $CaCO_3$ and soil pH of urban areas of Karachi. This was achieved by collecting the soil samples from different urban sites of the city. The goal of our study was to record the chemical characteristics and explain variability in urban soils in two different seasons (Autumn and winter). It was done by measuring the chemical properties of soils taken from various sites of the city. The obtained research database relating to seasonal changes in urban soils was found minimal, and we hope the findings will contribute in the field of ecology and to this growing area of interest in future studies.

MATERIALS AND METHODS

Site description

Karachi city lies in the Southern part of Pakistan. The district of Karachi is 2035 square kilometer. Physio-graphically, the study sites are almost dry, calcareous, and rocky and have sandy soil surface. The area is above the sea level in the range of 20 – 200 cm. 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 the hottest months of the year with temperature as high as 43 degree centigrade while January is the coldest month with temperature as low as 5 degree centigrade. Rain in Karachi is seasonal, averaging less than 22 cm per year between June and September and rare for the reminder of the year. Occasionally, there are dry year too while strong coastal winds and better dew formation are the characteristics feature of Karachi (Iqbal and Shafiq, 1996). The ever growing high rates of population growth, construction of new structure, high rising buildings, and expansion of roads due to heavy traffic density, industrial and anthropogenic activities are influencing on the edaphic characteristics of the urban areas of city of Karachi since last couple of decades very rapidly. The University of Karachi is a Public University located in Karachi. The University campus is spread over 1,279 acres (5.18 km^2) of land, situated 12 km away from the city center of Karachi (Wikipedia, 2012).

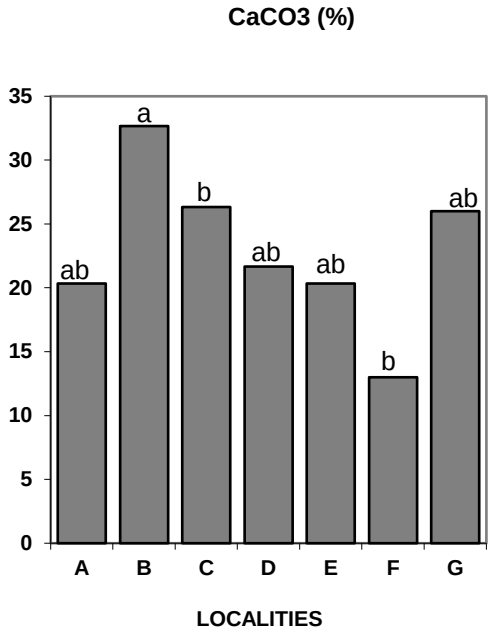
Soil sample collection

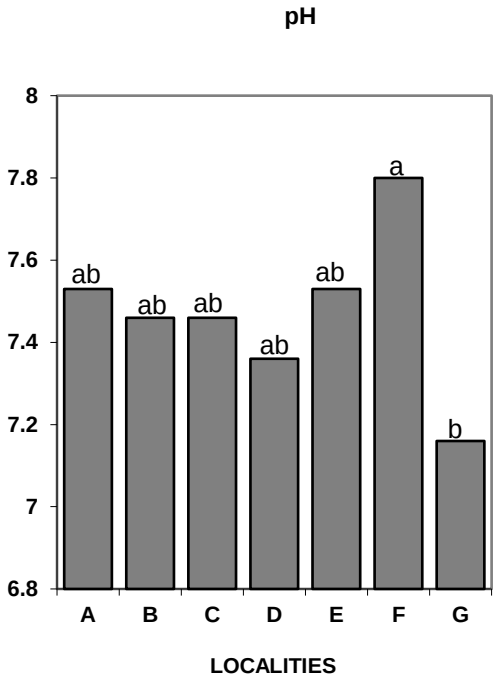
The composite soil samples were taken from seven different urban sites of the city of Karachi, viz. A=Karachi University, B=Manghopir, C=Patel Para, D=Cantt area, E= N.I.T.E. (New Karachi Industrial Trading Estate, Godhra Industrial Area New Karachi), F= K.I.T.E. (Korangi Industrial Trading Estate), G= S.I.T.E. (Sindh Industrial Trading Estate) in two different seasons autumn

and winter, respectively. Soil samples were taken from these sites at 20 cm depth. These samples were brought to the laboratory in polythene bags for chemical analysis and were kept in air for dried. The soil samples were passed through 2 mm sieve after drying. There were three replicates for chemical analysis. Calcium carbonate was determined by a method of acid neutralization, which was described by Qadir et al., (1966). The soil pH was determined by E.I.L. direct pH reading meter (Model Jenway PHM 6). Cat ions (sodium and potassium) were determined by flame photo meter (Model 410). All the data was statistically analysed by Analysis of Variance (ANOVA) and Student-Newman-Keuls Test at $p<0.05$ using personnel computer with software COSTAT version 3.

RESULTS

The chemical properties of the soil collected in autumn – winter period (October-December) from seven different urban sites (A=Karachi University, B=Manghopir, C=Patel Para, D=Cantt area, E=Godhra Industrial Area New Karachi (North Industrial Trading Estate, N.I.T.E.), F=Korangi Industrial Trading Estate (K.I.T.E.), and G= Sindh Industrial Trading Estate (S.I.T.E.) of city of Karachi were carried out. The results of the soil characteristics are given in Fig. 1-2.





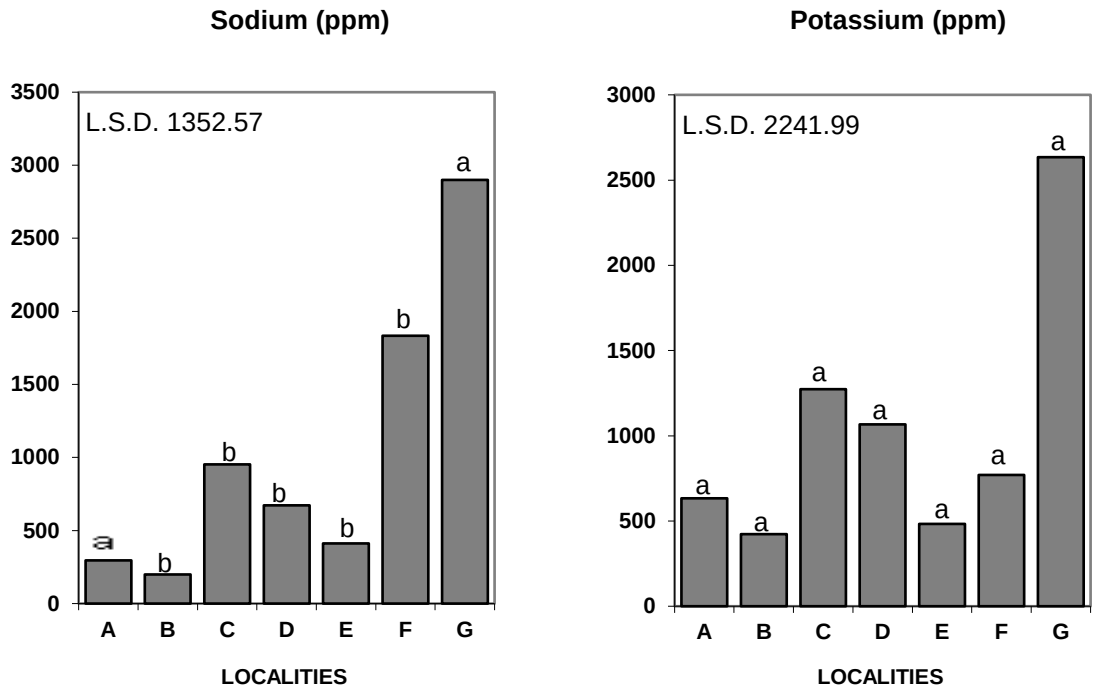


Figure. 1: Calcium carbonate $CaCO_3$ (%), pH, extractable sodium and potassium contents in soil during autumn season from different localities of city and industrial areas of Karachi. **Localities**. **A=Karachi University, B=Manghopir, C=Patel Para, D=Cantt area, E= N.I.T.E. (New Karachi Industrial Trading Estate, Godhra Industrial Area New Karachi), F= K.I.T.E. (Korangi Industrial Trading Estate), G= S.I.T.E. (Sindh Industrial Trading Estate)**

Number followed by the same letter on the same bar are not significantly different, according to Duncan's Multiple range test at P<0.05. L.S.D. for $CaCO_3$ (%) [11.34] and pH [0.38].

Overall, the soil of the study area was calcareous and alkaline in nature in both autumn and winter, respectively. There was no significant difference was found in soil pH among all soil samples in autumn season (Fig. 1). The soil pH of all the areas was moderate and alkaline in nature and ranging from 7.16 to 7.80 in autumn season. A significant ($p<0.05$) difference in calcium carbonate (%) was observed in same season of sampling from all sites. The soil of Manghopir area site had highest percentage of calcium carbonate (32.06%). The lowest concentration of calcium carbonate (13%) was found at Korangi Industrial Trading Estate (K.I.T.E.) area. Whereas, non- significant difference was found in potassium concentration was found in autumn season among all sites. The highest concentrations of potassium (2633.33 ppm) in soil of the SITE (Sindh Industrial Trading Estate) area were observed. The lowest concentrations of potassium (422.33 ppm) were found in the soil of Manghopir site. The highest concentrations of sodium (2950.33 ppm) in soil of the SITE (Sindh Industrial Trading Estate) area were recorded. The lowest concentrations of sodium (422.33 ppm) were found in the soil of Manghopir site.

The pH of soil value were found non-significant different in winter season at all the areas. In winter season the pH of the soil dropped to neutral and range from 7.06 to 7.43 (Fig. 2). Highest soil pH (7.43) was found at Manghopir site and lowest (7.06) at Cantt area. Significant ($p<0.05$) difference in sodium and potassium concentration was recorded in both seasons. Highest amount of sodium (2950 ppm) and lowest (200 ppm) was found in winter season of sampling at S.I.T.E. (Sindh Industrial Trading Estate) and Manghopir areas, respectively. Whereas, the highest (1963 ppm) and lowest amount of potassium (282 ppm) was found in winter season of soil sampling at Cantt and Manghopir areas, respectively.

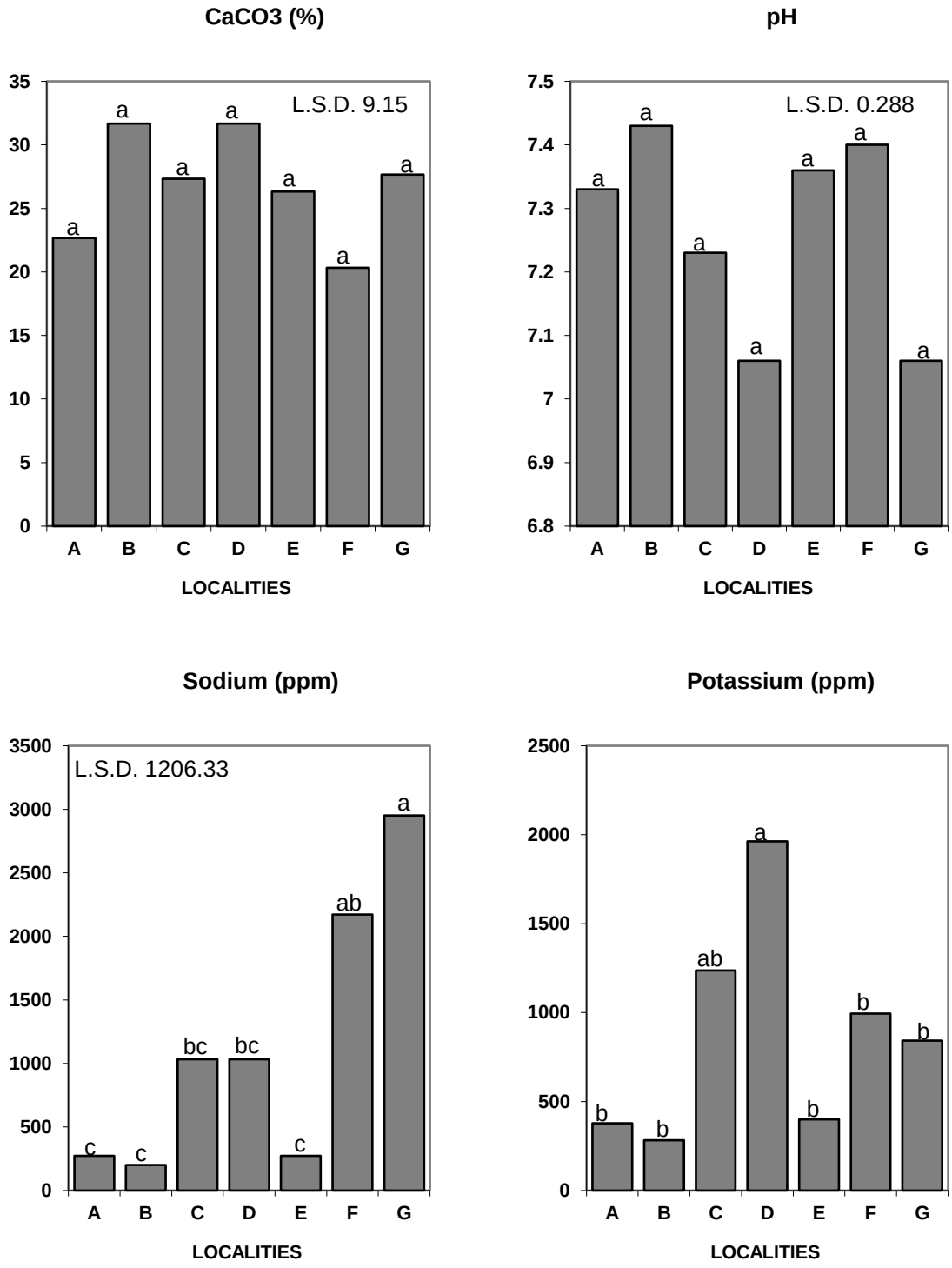


Figure 2: Calcium carbonate $CaCO_3$ (%), pH, extractable sodium and potassium contents in soil during winter season from different localities of city and industrial areas of Karachi. Localities. A=Karachi University, B=Manghopir, C=Patel Para, D=Cantt area, E= N.I.T.E. (New Karachi Industrial Trading Estate, Godhra Industrial Area New Karachi), F= K.I.T.E. (Korangi Industrial Trading Estate), G= S.I.T.E. (Sindh Industrial Trading Estate). Number followed by the same letter on the same bar are not significantly different, according to Duncan's Multiple range test at P<0.05. LSD. K+ [701.40]

DISCUSSION

One of the major difficulties in monitoring the environmental impact of anthropogenic disturbance on soil properties deals with the proper choice of a minimum data set of physical, chemical and biological properties (Gelsomino et al., 2006). Seasonal fluctuation in the soil characteristics was minor to differences due to anthropogenic and industrial activities. Knowledge of cationic and other elements in soil of the urban areas is an important from environmental point of view. The knowledge of city soil characteristic of Karachi urban and industrial area is scanty. Very limited study had been carried out in other parts of the city. In recent years, the research efforts of soil scientists and ecologists have converged to examine the crucial relations hip between soil biota and soil structure. Most research on soil structure in the century has focused on physical and chemical characterization of soil, often to the exclusion of biological influence. The acidity or alkalinity of the soil is defined by its pH. In present studies the soil pH was moderate and alkaline in nature, ranging from 7.16 to 7.80 and 7.06 to 7.43 in autumn and winter season of sampling, respectively. Unlike cation exchange capacity, pH is not a fixed characteristic of soil and varies over time and depending on a number of conditions. Soil is a critical component in the germination, growth and survival of plants. The well- developed industries releasing toxic substances which are modifying the nature, structure and composition of vegetation and soil (Iqbal et al., 1983). The soil of the studied area also showed an appreciable amount of calcium carbonate. In present investigation the soil of the study area showed difference in their chemical characteristics. An appreciable amount of calcium carbonate is a characteristics feature of arid zone soils (Aubert, 1960). Calcium carbonate is effective in reducing soil acidity by its ability to provide calcium and hydroxyl ions in the soil solution. The distribution, pattern and abundance of plant species and communities in desert environments has most often been released to three groups of factors; physical environmental variables affecting water availability, soil chemistry and anthropogenic disturbance (Enright et al., 2005). The results of soil chemical analysis revealed slight variation tendencies in the soils of industrial and University Campus area. Considerably high concentrations of Na and K were found in the industrial area soil in comparison with University Campus in autumn and winter season. This industrial site is located 20 Km from the University Campus. The concentration of cations, in autumn and winter season showed variation in soil characteristics of city and industrial areas of city. Similarly, high concentration of sodium and potassium content around the polluted disposal channels of S.I.T.E (Sindh Industrial Trading Estates) was found by (Iqbal et al., 1983).

It is concluded that certain environmental and anthropogenic activity were responsible for variation in soil characteristics. Karachi is the largest industrial area. These industries are using several chemical for their products and release untreated water in the area. Poor drainage system in the KITE (Korangi Industrial Trading Estate) is responsible for the slight changes in soil pH. The construction of new structure, varied human and industrial activities are changing the face of the flora and edaphic characteristics of the urban areas. It is concluded from the present findings that the ongoing activities demands the protection of the immediate environment. If such types of haphazard changes are allowed then probably there would be more edaphic changes will come in near future. Similarly, compared with natural forest, soil quality and soil fertility of urban green spaces of Beijing, China, were significantly decreased due to the strong interference of human activities, especially in roadside tree sites. Urban soil nutrient scarcity is the main reason that restricts soil microbial biomass nitrogen and the enzyme activity, and also the decisive factor that causes the variation of soil quality among different land use patterns. However, urban soil is interactively affected by numerous factors. Further studies on other factors, such as heavy metal pollution, soil temperature and vegetation types are needed to better reveal the influence mechanisms (Zaho, et al., 2012).

CONCLUSION

It was concluded that the seasonal variation in soil might be due to disturbances due to environmental factors in edaphic characteristic may cause differences in mineral nutrients status. The soil of the urban areas was alkaline and showed an appreciable amount of calcium carbonate. Whereas, the soil pH of all the seven different sites was found non-significantly different in autumn and winter season, respectively.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

MZI designed and supervised the experiment and AJ performed the experiment. MS wrote the manuscript. MK and ZRF reviewed the article. All author read and approved he final version.

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