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The soil quality assessment with reference to selected parameters of farmlands in Pune region, Maharashtra

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ABSTRACT

The soils provide the starting point for successful agriculture. Rapid increase in human population has increased the stress on natural resources, including the soil. Soil degradation influences agricultural production and also adversely affects other interrelated natural resources. Urban soils can present significant challenges for an urban farmer. Soil contaminants are more prevalent in the urban environment than rural one. Hence the present investigation was carried out to assess the soil quality for the selected parameters. For five urban farmlands which were selected for the sampling of the soils namely Agriculture College, Wakdewadi, Khadki, Chinchwad and Khadkwasala regions of the Pune city. Soil pH of all the selected sites was found to be slightly alkaline in nature. Electrical conductivity was highest in sample S_2 i.e. 218.83 µS while the minimum of 157.89 µS in sample S_5. Total dissolved solids content was observed to be highest viz. 115.64 ppm in sample S_5 while it was minimum of 98.26 ppm in sample S_1. Maximum value for organic carbon content observed was 1.24 % in S_4 sample while it was minimum at control site with a value of 0.66%. Highest value for nitrogen was observed in S_4 viz. 0.47% while it was minimum of 0.25% in S_3. The details of the remaining parameters are discussed in further paper.

KEYWORDS

Heavy metals;
Land use;
Micronutrients;
Physico-chemical parameters;
Soil management;
Soil quality.

INTRODUCTION

The rapid increase in human population has increased the stress on natural resources, like soil. Doran and Parkin[1] identified the three main functions of soil, as a medium for plant growth, to regulate and partition the water flow and to serve as an environmental buffer. The soil quality is the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health[2]. Indicators of soil quality should be responsive to management practices, integrate ecosystem processes, and be components of existing, accessible data bases. However, management of soils for a specific application should not preclude changes in land use in the future[3].

Overuse of pesticides, inorganic fertilisers, increased liquid and solid waste disposals, improper irrigation practices, landfill leachates are some of the broad reasons behind the degradation of lands. The long-term development of global socio-economic systems requires the sustainable use of natural resources which is related to soil quality. In the last decades, with the progress of the sustainability paradigm, the formulation of metrics and indices of sustainability of systems (social economic and environmental systems) and sustainable development evolved and produced comprehensive indexing methods[4]. During the same time, based on the results of corresponding scientific research and available information[5,6] major development of soil conservation policy has taken place in the European Union[7].

A soil quality is determined by a set of many highly correlated physical, chemical, and biological properties such as soil depth, water-holding capacity, bulk density, nutrient availability, potential capacity, organic matter, microbial biomass, carbon and nitrogen content, soil structure, water infiltration, and crop yield. Many such combinations of soil attributes have been suggested as indicators of soil quality[8]. Poor soil quality can produce lower agricultural yields, a less resilient soil and land ecosystem, and increase contamination of adjacent water bodies[9]. Declining soil quality is emerging as an environmental and economic issue of increasing global concern as degraded soils are becoming more prevalent due to intensive use and poor management, often the result of over-population[10]. Measures of soil quality include monitoring of long-term effects of farming practices on soil properties; assess the economic impact of alternative management practices designed to improve soil quality (such as cover crops and alternative tillage practices); assess the effectiveness of policies designed to address factors affecting soil quality; and improve economic assessments of land by including both economic and environmental values while biological indicators represent different aspects of soil quality in different ecosystems[11]. These indicators strive to monitor or measure three basic functions or parameters like soil structure development, nutrient storage and biological activity. Many indicators relate to the cycling of soil organic matter, a key component of soil quality[12]. It is a reactor, transformer and integrator of material and energy from other natural resources (solar radiation, atmosphere, surface and subsurface waters, biological resources), a medium for biomass production; storage of water, nutrients and heat; natural filter and detoxification and buffering system; an important gene-reservoir; and a medium of past and present human activities[5].

Soil quality can be assessed by numerous soil variables[13]. In addition to physicochemical variables, biotic variables also reflect soil quality[14]. Soil variables often show different patterns of response to the same impact[15], reflecting the multidimensional quality of soil health[16]. These soil variables are associated with different soil-related variables, including crop yields. Therefore, analysis of multiple soil biotic variables can provide comprehensive and multidimensional information[17]. Once pollutants are incorporated in to the soil, their concentration in soil may continuously increase and cause toxicity to all forms of life like plant, micro organism and human beings[18,19]. Land evaluation models may serve as a first step to develop a soil quality assessment procedure[20]. In Sub-Saharan African countries, soil fertility depletion is the fundamental biophysical cause for declining per capita food production[21]. Inappropriate land use aggravates the degradation of soil physicochemical and biological properties[22]. Maddonni et al.[23] reported that land use affects basic processes such as erosion, soil structure and aggregate stability, nutrient cycling, leaching, carbon sequestration, and other similar physical and biochemical processes.

Urban soils can present significant challenges for an urban farmer. Soil contaminates are more prevalent in the urban environment, making it essential to review the history of the farm site and survey the surroundings for potential contaminants. For the same the present investigation was carried out to asses the soil quality for the selected parameters. Five urban farmlands were selected for the sampling of the soils namely Agriculture College, Wakdewadi, Khadki, Chinchwad and Khadkwasala regions of the Pune city.

EXPERIMENTAL

The study area Pune, Maharashtra is located within 18° 31' N latitude and 73° 55' E longitudes. The major annual and perennial crops grown in the study area are maize, sorghum, sweet potato, haricot bean, mango and sugarcane. Soil samples were collected from five different locations of the city. Surface soil of 3 cm depth was collected for the analysis. Soil samples were air dried, crumbled and sieved through 2 mm screen. All samples were stored in suitable polythene receptacles[24]. These samples were then investigated quantitatively for physical and chemical properties.

The pH meter was calibrated by using 4.0 and 9.1 buffer solution. The pH of 1:10 Soil: deionised water suspension was determined by calibrated pH meter at 29.7 ^{0}C. Electrical Conductivity (EC) and Total Dissolved Solids (TDS) of the dried and well sieved soils were determined by preparing 1:10 soil suspension in water. This suspension was vigorously shaken, allowed to stand for 12 h and then filtered through Whatman No.1 filter paper for analysis. Both the parameters were determined by using Elico EC-TDS meter. The Moisture content was determined by oven-drying the soil sample (Gravimetric method) and expressed as percentage where loss of weight of the samples was calculated to determine the moisture content.

Organic carbon was estimated by rapid dichromate oxidation technique, the method suggested by Walkely and Black while the organic matter was estimated from the result of organic carbon by a multiplication factor of 1.724. Total Nitrogen was determined with Kjeldahl's method[25]. Boron, Carbonate and Bicarbonates were estimated by the standards methods[26]. The Available Phosphorus was determined by the method suggested by Olsen et al.[27]. Four selected inorganic constituents like Cu^{++}, Zn^{++}, Fe^{+++} and Ni^{++} were estimated from oven dried soil samples by using Atomic Absorption Spectrophotometer (Perkin-Elmer, 3030 A). All chemicals used for the estimation of various parameters were of AR grade.

STATISTICAL ANALYSIS

Statistical analysis of the data was carried out by using GraphPad software. Mean and Standard Deviation was calculated. 'One Way Analysis of Variance' (ANOVA) was tested in order to see the statistical difference among the means. Site S_1 (Agricultural soil) is considered as control site. Tukey-Kramer multiple comparison test of significance was carried out which suggested the variation among the column means is significant or not at different levels of significance. The data was analysed for three different levels of significance based on the 'p' values as

* Significant (p = 0.01 to 0.05), ** Very Significant (p = 0.001 to 0.01) and *** Extremely Significant (p < 0.001.

RESULT AND DISCUSSION

TABLE 1 : Soil quality analysis of the selected farmlands of Pune region

Sr. No.	Parameter studied	Soil sampling sites				
		S_1	S_2	S_3	S_4	S_5
1	pH	8.47 (±0.15)	8.43* (±0.25)	8.69** (±0.31)	8.43 (±0.18)	8.12*** (±0.19)
2	Electrical Conductivity µS	186.33 (±16.32)	218.83** (±12.58)	192.07* (±18.94)	200.28*** (±15.62)	157.89*** (±8.94)
3	Moisture Content %	7.63 (±1.01)	6.05* (±0.56)	9.23*** (±0.34)	10.54*** (±0.98)	11.41* (±1.05)
4	Total Dissolved Solids (ppm)	98.26 (±3.56)	112.36** (±6.48)	104.94** (±7.98)	106.70*** (±8.46)	115.64*** (±11.84)
5	Organic Carbon %	0.66 (±0.15)	0.89** (±0.11)	0.95*** (±0.19)	1.24* (±0.24)	1.08*** (±0.34)
6	Organic Matter %	1.14 (±0.24)	1.53*** (±0.28)	1.63** (±0.34)	2.13** (±0.19)	1.86*** (±0.14)
7	Kjeldahl's Nitrogen %	0.42 (±0.08)	0.34* (±0.07)	0.25*** (±0.09)	0.47*** (±0.06)	0.33*** (±0.07
8	Carbonate (calcium) (ppm)	0.16 (±0.07)	0.25** (±0.06)	0.31** (±0.05)	0.18** (±0.04)	0.19** (±0.05)
9	Bicarbonate (ppm)	0.81 (±0.11)	0.51*** (±0.09)	0.64*** (±0.07)	0.54** (±0.07)	0.72*** (±0.08)
10	Available Phosphorus (ppm)	10.23 (±1.12)	11.34*** (±1.16)	13.54*** (±2.01)	8.54*** (±0.98)	9.74** (±1.20)
11	Boron (ppm)	0.49 (±0.08)	0.58* (±0.07)	0.92** (±0.09)	0.88* (±0.06)	0.72* (±0.09)
12	Copper (ppm)	8.91 (±1.56)	7.22*** (±1.21)	5.68*** (±0.85)	6.64* (±0.89)	8.14* (±0.92)
14	Nickel (ppm)	7.32 (±1.22)	6.45* (±1.24)	3.64** (±0.18)	4.87*** (±0.25)	6.54*** (±0.38)
15	Zinc (ppm)	52.46 (±3.65)	41.65** (±4.25)	62.71** (±3.64)	38.45** (±2.18)	46.18** (±2.54)
13	Iron (ppm)	3689.78 (±21.56)	3254.14* (±18.65)	3986.27** (±13.78)	2882.95** (±15.64)	2649.29*** (±17.24)

S_1 - Agriculture College (Control site), S_2 - Wakdewadi, S_3 - Khadki, S_4 - Chinchwad, S_5 - Khadkwasala
Each value is a mean of three determinations
Values in parenthesis indicate standard deviation

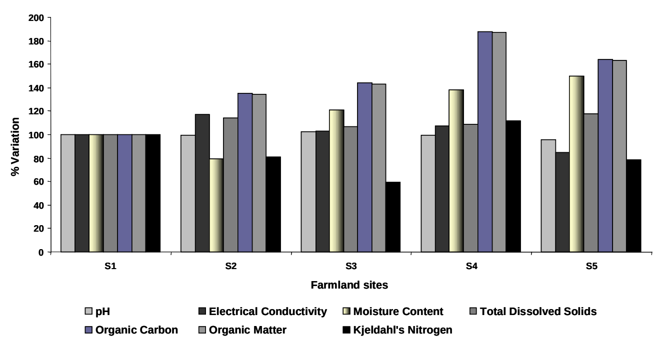

Figure 1 : Soil quality analysis of farmlands in Pune

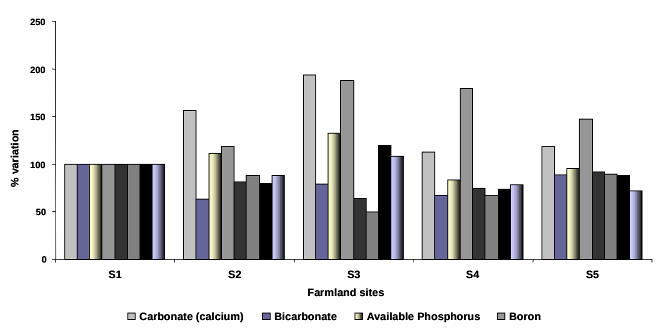

Figure 2 : Soil quality analysis of farmlands in Pune

The pH value is a measure of hydrogen or hydroxyl ion concentration of the soil water system and indicates whether the soil is acidic, neutral or alkaline in reaction. Crop growth suffers much both under very low as well as high pH. The pH of a soil also controls the availability of many nutrients to plants and the solubility of some trace elements. Crops are chosen based on soil pH, suitable techniques are employed to obtain high yield and product quality. Soil pH of all the selected sites was observed to the slightly alkaline in nature. Agricultural site S_1 (control) showed a pH as 8.47 while at S_5 the pH was observed to be minimum by 8.12. Electrical conductivity was highest at S_2 by 218.83 μS while that was minimum by 157.89 μS at S_5. No much variation was observed in relation with the EC of the different soils. Moisture content of the soil quality of two sites at the defense establishments was observed by Bra et al.[28] where they further observed that the soil moisture content was about 0.4 to 1 percent at two selected the sites and the moisture content capacity is more at deep level than at the surface level. In the present investigation moisture content was varying in the range of 6.05 % (minimum) at site S_2 while it was highest at S_5. Total Dissolved Solids (TDS) content was observed to be highest by a value of 115.64 ppm at S_5 while it was minimum by a value of 98.26 ppm at S_1. Good amount of dissolved solids were observed to be present in the soils of the selected farmlands.

Changes in soil Organic Carbon (OC) are often used as one of the indicators of changes in soil quality. Organic Matter (OM) content helps soils retain moisture and nutrients and gives good soil structure for water movement and root growth. Soil organic matter is important for nutrient availability, soil structure, air and water infiltration, water retention, erosion and the transport or immobilization of pollutants. The soil quality of two sites at the defense establishments observed with the total organic carbon values ranged from 18 mg g^{-1} to 75 mg g^{-1} for both the sites[28]. In general, most of soils selected contain organic carbon lower than 1.26%. Maximum value for organic carbon content was observed to be 1.24 % at S_4 while it was minimum at control site with a value of 0.66%. Similarly organic matter content was observed to be highest by a value of at S_4 and with a lowered value at S_1. All the farmlands were with sufficient amount of OC and OM which might enhance the better crop growth and yield.

As all the selected sites were with good amount of organic matter, total nitrogen content is also observed in sufficient amount. Higher value for nitrogen was observed at S_4 by 0.47% while it was minimum by a value of 0.25% at S_3. Total Kjeldahl's nitrogen at the defense establishment sites ranged from 1100 mg kg^{-1} to 1900 mg kg^{-1} for site I and 1700 mg kg^{-1} to 9000 mg kg^{-1} for site II[28]. Carbonates dissolved in water can move up in the soil profile due to capillary action, and are often deposited at or near the soil surface after water is evaporated. These significantly increase soil pH with continued farming. In light of the probable continuance of subsidence in the future, soil pH can be expected to continue to increase, which will result in decrease in the availability of plant nutrients to crops. Bicarbonate and Carbonate ions combined with Calcium or Magnesium precipitate as Calcium carbonate ($CaCO_3$) or Magnesium carbonate ($MgCO_3$) when the soil solution concentrates in drying conditions. Highest value for Carbonate was observed at S_3 with a value of 0.3 ppm while minimum value was recorded at S_1 with a value of 0.16 ppm. Values for Bicarbonates were observed to be varying similar to Carbonates and lowest value for Bicarbonates was by a value of 0.51 ppm at S_2. Phosphorus is an essential nutrient both as a part of several key plant structures compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds. Values for Available Phosphorus were varied in the range of 8.54 at S_4 to by a highest value of 13.54 at S_3.

Trace elements occur naturally and the natural concentrations of most trace elements can vary greatly depending on geologic parent material[29]. Some trace elements are essential micronutrients for plants and animals while others are not. However, both essential and non-essential elements can become toxic at higher concentrations[30]. The deficiency or excess presence of micronutrients such as iron, zinc and copper may produce synergetic and antagonistic effects in the plants[31]. Both essential and non-essential trace elements can become toxic at high concentrations. Trace elements can accumulate in the soil from various common agricultural and horticultural land use activities. Excessive use of these macronutrients could affect the soil pH which in turn affects the availability of the micronutrients. The availability of the micronutrients Manganese, Iron, Copper, Zinc and Boron tend to decrease as pH increases[32]. Effluents on soil surface and which was percolated in soil causes imbalance in micronutrients content[33].

In the present study the value of Boron was observed as higher by 0.92 ppm at S_3 and the value was not much varying as compared to the other selected sites. Similarly copper and Nickel content was observed to be lower as compared to the values of Zinc. Copper content ranged by a minimum of 5.68 (S_3) to 8.91 ppm (S_1) while that of Nickel content varied from a minimum of 3.64 (S_3) to 7.32 ppm (S_1). Zinc content ranged in between 38.45 (S_4) to 62.71 (S_3). Similarly Iron content ranged in by a minimum of 2882.95 (S_4) to 3986.27 ppm (S_3). As Iron is more essential than other three selected nutrients its values were observed to be much higher.

CONCLUSION

Soil pH of all the selected sites was observed to be slight alkaline in nature. No much variation was observed in relation with the EC of the soils. Similar results were obtained in case of moisture content. Good amount of dissolved solids were observed to be present in the soils of the selected farmlands. All the farmlands were with sufficient amount of organic carbon (OC) and organic matter (OM) which might enhance the better crop growth and yield.

The selected micronutrients are found in abundance at all the selected sites. The soil quality of all the areas studied is good as all the nutrients and other parameters are not varying much as compared to the control site (Agricultural Site). But in future due to increasing urban contaminants and leachates there is threat to the soil quality. Overuse of pesticides and fertilizers might also cause the negative impact on the fertility of the soils in selected areas and further work in this aspect is needed. There is a need for an integrated approach that recognizes the physical, biological and chemical processes in soils. The use of a holistic test and procedures that provides information about the three aspects of soils physical, biological, and chemical will be more meaningful approach to monitoring soil quality.

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