GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

www.scienceandnature.org

SOIL QUALITY UNDER BASALTIC LANDFORMS OF RAHAT WATERSHED, MAHARASHTRA

Stanzin Lakdan, S.S. Balpande, A.R. Mhaske & R.M. Ghodpage
College of Agriculture, Dr. PDKV, Nagpur, India.

ABSTRACT
Soil quality in Rahat watershed of Nagpur district was assessed with respect to landforms and land use for better management of land resources. Among the all variables from the minimum data set, SOC emerged as a key indicator contributing 38.85% towards SQI. SQI of soils of alluvial plain ranged between 1.37 and 2.89. The wide variation might be attributed to management of SOC in single and double cropland. The contribution of SOC was highest among all soil quality indicators. In the pediment region of Rahat micro-watershed the SQI ranged between 1.00 in wasteland landform to 3.02 in grassland landform. The crop land showed wide variation in SQI. Forest area in the plateau region showed medium SQI (2.220) due to the better biological properties. Alluvial plain had highest SQI (2.005) among all topography followed by plateau top (1.777) and the last pediment (1.731). The SQI in Rahat micro-watershed ranged from 0.972 to 3.022.

KEY WORDS: soil quality index, landforms, Land use, Minimum data set.

INTRODUCTION

The soil quality helps to obtain the information necessary to evaluate the sustainability of agriculture or any other land use practice. . The need for assessing soil quality as an element of agro-ecosystem sustainability is a rational response to these societal concerns. Most soil quality research efforts intend to use science for better decision making regarding soil management practices and to make the best use of the finite soil, water and energy resources. Soil quality (SQ) monitoring supports land managers to scrutinize the sustainability of land use systems. In other words, understanding SQ leads to management systems that optimize soil functions for the current and future generations (Andrews *et al*., 2004). Improving SQ can provide economic benefits in the form of increased productivity; nutrient and pesticides use efficiency, water and air quality enhancement and amelioration of greenhouse gases. There is no standard to which SQ indicators can be compared, but higher soil quality index (SQI) numbers are interpreted as higher soil quality. Establishing a functional relationship between SQ and SQ indicators is decisive in SQ assessment. However, such functional relationships cannot always be established empirically. The Rahat micro-watershed occurs in the basaltic terrain of Nagpur district of Maharashtra. The mean annual rainfall is 1050mm. The area is predominantly under rain fed farming with erratic rainfall distribution associated with low crop productivity. The present study is useful to improve soil quality and productivity through better site-specific (and soil specific) management decisions in the Rahat watershed.

MATERIALS & METHODS

Geographically, the Rahat micro-watershed is located between 78^o 33’ to 78^o 36’E longitudes and 21^o 04’ to 21^o 06’N latitudes in Katol tehsil of Nagpur district, Maharashtra. The total area of the watershed is 363.02 ha. Rahat micro-watershed area was divided into four major physiographic units (1) Plateau (2) isolated mound (3) Pediment (4) Alluvial plain and further sub-divided based on slope and land use/land cover. Fields from each landform, total about 40 soil-samples were taken for study from three different landforms. Representative soil samples from each field were collected using standard procedure. Soil samples collected from the surface at depth of 0-20cm were dried in shade. The air-dried samples were ground with a wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (>2 mm). The standard analytical methods were adopted for estimating the various parameters in the laboratory. Assessment of soil quality was done using the following steps as suggested by Doran and Parkin, 1994; and Andrew *et al*., 2002. For the assessment of soil quality, First of all fifteen parameters were used for principle component analysis and the minimum data set was selected. The scoring of minimum data set was done and the soil quality index was computed using following equation.

$$SQI = \sum_{i=1}^{n} si.wi$$

Where, s =score for subscripted variables
w = factor loading derived from PCA.

RESULT & DISCUSSION

In the Principle component analysis (PCA) of 15 variables six PCs had value >1 and explained 79% of the variance in data (Table 1). Highly weighted variables under PC1 included BD, silt, clay and Mn. A correlation matrix for highly weighted variable under different PCs was run separately. It was assumed that the variables having highest correlation sum were best represented the group.

TABLE 1. Principal component analysis (PCA) of soil quality indicators

PC'S	PC1	PC2	PC3	PC4	PC5	PC6
Eigen value	5.2	4.3	2.00	1.9	1.5	1.1
% of variance	26.05	21.27	10.02	9.36	7.79	5.25
Cumulative%	26.05	47.32	57.35	66.71	74.42	79.68
Factor Loading/ Eigen value Variable						
BD	0.8878	-0.0540	0.3712	0.0837	-0.1095	0.1082
Sand	0.3614	-0.0687	0.5266	0.4007	-0.0446	-0.4041
Silt	0.8063	-0.0359	0.1057	-0.1246	-0.1455	0.4082
Clay	-0.8718	0.0665	-0.3868	-0.1173	0.1415	-0.1295
AWC	-0.3330	0.1708	0.2513	0.4276	0.3497	0.0542
HC	0.0053	-0.3793	0.3281	0.2227	-0.5144	0.0771
pH	-0.7872	0.3138	0.2240	0.0163	-0.0854	0.1944
EC	-0.5563	0.3655	0.1219	0.3649	0.1902	0.3823
SOC	0.1319	0.8452	-0.0093	0.3175	-0.2339	-0.0737
CaCO3	-0.6396	0.0289	-0.0741	0.2796	-0.4052	-0.1219
N	0.0284	0.8017	0.0285	0.4010	-0.2734	-0.0407
P	0.0006	0.1653	0.5084	-0.2043	0.5328	0.3853
K	-0.2726	0.3075	0.7253	0.0323	0.0486	-0.1405
Fe	0.6747	-0.1015	-0.3680	0.4539	0.1570	0.0484
Cu	0.0357	0.1797	-0.4276	0.6649	0.2808	0.2045
Zn	0.1702	0.1806	0.1320	-0.0146	0.5789	-0.5056
Mn	0.7920	-0.0632	-0.1800	0.2174	0.1647	-0.0696
DHA	0.2881	0.8605	-0.0948	-0.2967	-0.0809	0.0305
MBC	0.2760	0.8671	-0.0603	-0.2808	-0.0615	-0.0228
MBN	0.2613	0.8852	-0.1461	-0.2529	-0.0015	-0.0596

TABLE 2. Correlation matrix for highly weighted variables under PC's with High factor loading

Variables	B.D	Silt	Clay	Mn
PC1 variables Pearson'Correlation				
B.D	1.000	0.809**	-0.976**	0.617**
Silt	0.809**	1.000	-0.835**	0.525**
Clay	-0.976**	-0.835**	1.000	-0.588**
Mn	0.617**	0.525**	-0.588**	1.000
Correlation sums	3.402	3.169	3.399	2.730
PC2 variables	SOC	DHA	MBC	MBN
Pearson'Correlation				
SOC	1.000	0.635**	0.626**	0.660**
DHA	0.635**	1.000	0.969**	0.953**
MBC	0.626**	0.969**	1.000	0.968**
MBN	0.660**	0.953**	0.968**	1.000
Correlation sums	2.921	3.557	3.563	3.581
PC3 variables	K			
Pearson'Correlation				
K	1.000			
Correlation sums	1.000			
PC4 variables	Cu			
Pearson'Correlation				
Cu	1.000			
Correlation sums	1.000			
PC5 variables	HC	P	Zn	
Pearson'Correlation				
HC	1.000	-0.038	-0.094	
P	-0.038	1.000	0.260	
Zn	-0.094	0.260	1.000	
Correlation sums	1.132	1.298	1.354	
PC6 variables	Sand	Silt	Zn	
Pearson'Correlation				
Sand	1.000	-0.05	0.127	
Silt	-0.05	1.000	-0.049	
Zn	0.127	-0.049	1.000	
Correlation sums	1.177	1.099	1.176	

*Significance at P = 0.05 ** Significance at P = 0.01

Among the four variables in PC1, BD was chosen for minimum data set (MDS), because of highest correlation sum. Silt and clay was eliminated because of highest correlated with BD (r=0.81 and -0.98) and DTPA Mn has the lowest correlation sum and was eliminated because of high availability of Mn in basaltic region. In PC2, Soil organic carbon (SOC), dehydrogenase activity (DHA), microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN) were highly weighted. SOC and MBN were retained because of their relative importance in subtropical region.DHA was eliminated because it was high correlated with MBN (r=0.95) and also MBC was dropped from MDS because of high correlation with MBN (r=0.97).

Available K was another variable, which qualified under PC3.The DTPA-Cu was also qualified under PC4 and was considered under MDS because occurrence of frequent deficiencies of micronutrients in soils of the region (critical limit <0.20 mg kg^{-1}). Although DTPA Zn was found as a highly weighted variable under PC5, it could not be retained because it was not correlate with hydraulic conductivity (HC). Available P was also eliminated because of less correlation with HC. HC was retained under PC5 because of its importance in clayey soils. At last in PC6, sand had highest correlation sums followed by Zn. Both were eliminated because of its higher correlation with BD and also silt was dropped from MDS because it was not correlated with sand and zinc. Andrews *et al*. (2002) reported that choice among well-correlated variables could also be based on the practicability of the variables.

The selection of the site specific MDS is most often based on expert opinion (Doran and Parkin, 1994), although statistical procedures, such as principal components or factor analysis can also be used (Andrews and Caroll, 2001). The multiple regression functions involved all variables within the MDS. It explained more than 79% (Table 1) of the variance. The BD and Cu was slightly less predictive (coefficient of determination (R^2)=0.456).BD, Cu and HC had R^2=0.559 and BD,HC,SOC and MBN has R^2=0.652 which had highest multiple regression among all the MDS variables(Table 3).

TABLE 3. Testing the MDS through multiple regression analysis

Sr.no	Most significant MDS variables	R^{2**}
1.	BD, Cu	0.456**
2.	BD, Cu, HC	0.559**
3.	BD, HC,SOC,MBN	0.652**

** Significant at 0.01 level

There are various ways of scoring and combining indicators into indices (*e.g.* linear, non linear, optimum, more is better, more is worse) depending upon the soil function (Andrews and Caroll, 2001). For BD is taken as "less is better" because of the inhibitory effect on root growth and porosity; the site specific factor are texture and inherent mineralogy, SOC is a "more is better" function based on its roles in soil fertility, water partitioning, and structural stability; the site-specific factors are inherent organic matter, texture and climate. MBN is a "more is better" function based on its role in mineralization, denitrification and soil enzyme in the soils. It also indicates the fertility and microbial population in the soils; the site specific factor is organic matter, soil moisture and pH. HC is "more is better" function based on its role of drainage, water storage, nutrient solubility, and biological activity; the site specific factors are texture and inherent organic matter. The statistical relation of BD with HC (Table 4) revealed that BD showed significant positive correlation with HC (r = 0.320**). The correlation of BD with SOC showed significant negative relationship (r=0.515*).Significant negative correlation was observed in BD and MBN content (r = 0.533*) HC had also significant positive correlation with SOC. The correlation study of HC showed non significant correlation with MBN (r = 0.012).The SOC show positive significant relationship with MBN (r = 0.451*).

TABLE 4. Correlation coefficient between Minimum Data Set (MDS)

Parameters	BD	HC	SOC	MBN
BD	1.000			
HC	0.320**	1.000		
SOC	-0.515*	0.419*	1.000	
MBN	0.533*	0.012	0.451*	1.000

*****Significant at 0.01 level **Significant at 0.05 level

All the four variables BD, HC, SOC and MBN of MDS influence the SQI significantly. Main effects of residue and SOC levels on SQI were significant. Increasing SOC levels also helped in maintaining higher SQI values. HC was proved to be quite effective in maintaining soil quality under basaltic landforms.. Among the all variables from the minimum data set, SOC emerged as a key indicator contributing 38.85% towards SQI. It also served as a sensitive indicator of change and in organic matter levels and equilibrium. The Soil Quality Index values indicated that SQI ranged from 0.97 to 3.02 (Table 5). Highest SQI 3.02 was obtained in grassland of pediment topography followed by SQI of 2.88 on very gentle slope with cultivable single crop of alluvial plain. The Lowest SQI of 0.972 values was obtained under wasteland from plateau top, suggesting less availability of SOC and less microbial activities in these soils. The grassland of pediment landform had the highest SQI of 3.022 whereas the lowest SQI of 1.213 was observed in wasteland of plateau top (Table 5). In plateau top of forest soil the SQI was 2.22 due to better biological properties whereas wasteland of plateau showed SQI of 1.213, the lowest among all landform due to less availability of organic matter.

Cultivated double crops showed the SQI of 1.822 and in cultivated single crop SQI was 2.074.

TABLE 5. Soil Quality Index in Rahat micro-watershed

Sr.No.	Landform type/ Land Use	No. of samples	Sample No.	SQI	Average SQI
1.	Plateau Top	7			
a.	Forest	1	1	2.220	
b.	Wasteland	2	2	1.455	
			11	0.972	1.777
c.	Cultivated Double crops	2	9	1.890	
			10	1.754	
d.	Cultivated Single crop	2	12	2.072	
			13	2.076	
2.	Pediment	17			
a.	Grassland	3	4	1.705	
			5	3.022	
			6	2.060	
b.	Very gentle slope with Single crop	6	7	2.318	
			8	2.130	
			26	1.391	1.731
			27	1.695	
			29	1.112	
			33	1.177	
c.	Double crops	3	28	2.055	
			30	1.000	
			31	1.161	
d.	Wasteland	2	14	1.835	
			32	1.487	
e.	Gentle slope with Single crop	2	15	1.529	
			16	2.438	
f.	Gentle slope wasteland	1	3	1.320	
3.	Alluvial plain	16			
a.	Very gentle slope with cultivable single crops	4	22	1.471	
			23	2.257	
			24	2.885	
			25	1.375	
b.	Alluvial Plain cultivated double crops	9	17	1.847	
			18	2.570	2.005
			19	2.815	
			20	1.525	
			21	2.089	
			34	1.927	
			35	1.818	
			36	1.955	
			37	1.535	
c.	Level alluvial plain with single crop	3	38	1.676	
			39	2.225	
			40	2.115	

REFERENCES

Andrews, S.S., Karlen, D.L. & Cambardella, C.A. (2004) the soil management assessment framework; A quantitative soil quality evaluation method. *J.soil sci.soc. America* **68**(6): 1945-1962.

Andrews, S.S. & Carroll, C.R. (2001) Designing a decision tool for sustainable agroecosystem management: Soil quality assessment of a poultry litter management case study. *Ecology application* **11**(6): 1573-1585.

Andrews, S.S., Mitchell, J.P., Mancinelli, R., Karlen, D. L., Hartz, T.K., Howarth, W.R., Pettygrove, G.S., Scow, K.M. and Munk, D.S. (2002) On – farm assessment of soil quality in California's central valley. *Agronomy Journal*.**94**: 12-23.

Doran, J.W. & Parkin, T.B. (1994) Defining and assessing soil quality. In Doran,J.W., Coleman, D.C., Bezdicek, D.F., Stewart, B.A.(Eds.) *Defining Soil Quality for a Sustainable Environment. Soil Sci. Soc. America,* Inc, Madison, WI, USA. 3-21.