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Assessment of Soil Quality Using Geospatial Modeling

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INTRODUCTION

Agricultural activities in many parts of the world have resulted in a large decline in soil organic matter (SOM) and concomitant degradation of soil fertility, resulting in reduced crop yields and soil quality. Soil quality assessment may be one of the most contentious topics ever discussed in the soil science community. The soil quality is attracting attention for the last couple of years due to the unscientific and unplanned irrigation practices that are bringing a myriad of problems. Soil quality evaluation has widely been accepted as a vital step towards realizing the long-term consequences of various land management practices. Geospatial techniques involving the use of RS, Global Positioning System (GPS) and GIS, provide new approaches for studying various soil quality aspects in different spatial as well as temporal domains (Schiewe, 2003). It has been widely documented as a vital tool for soil/land resource inventory at different scales extending from local to regional and even up to global scale. Soil quality is defined as "the ability of soil to function within ecosystem boundaries to maintain biological productivity, maintain environmental quality, and promote plant and animal health."

Soil Quality Assessment

Soil quality assessment is required to assess the sustainability of soils under the present ecosystem as well as to predict the sustainability of the ecosystem for the future of the present environmental conditions.

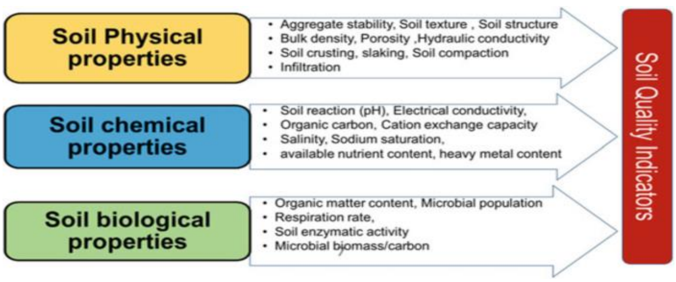

Fig. Different types of soil quality indicators

Soil Quality Indices are Simple Ratio Based Index, Multiparametric Soil Quality Index, NIR Spectra for Measurement of Soil Quality, Spectral Soil Quality Index (SSQI), and Fertility Capability Soil Classification (FCC) System. The minimum data set (MDS) for evaluating soil quality is the smallest set of chemical, physical and biological indicators that account for the variability in the whole soil data set at each site obtained through multivariate statistical techniques. Principal Component Analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set.

Geospatial Modeling

Geospatial techniques widely used for soil quality assessment and mapping include visual interpretation of both aerial and satellite images to delineate soil physiographic units that form the basis of soil survey and characterization. Components of Geospatial Technology are remote sensing, GPS, and GIS. Remote Sensing is a technique of deriving information about objects on the surface of the earth without physically coming into contact with them. GPS is a network of satellites (24 total- 21 in use, 3 spares) that continuously transmit coded information, which makes it possible to precisely identify locations on earth by measuring the distance from the satellites. GIS is defined as a powerful set of computer-based tools for collecting, storing, retrieving, and displaying spatial data from the real world for a particular set of purposes.

Modeling used for Soil Quality

SOC is one of the most commonly recognized indicators of soil quality. It acts as a functional part of the ecosystem and improves various soil properties such as soil structure, fertility and water holding capacity. The models used for soil quality are

1.Rothamsted carbon model (RothC)

This model is widely used to simulate soil C dynamics in cropland and other land-use systems and management practices.It can predict reasonably good SOC dynamics results. RothC is a model for the turnover of organic carbon in non-waterlogged top soils that allows for the effects of soil type, temperature, moisture content and plant cover on the turnover process (Jenkinson *et al*., 1977).

Data required to run the model are Monthly rainfall (mm), Monthly open pan evaporation (mm), Monthly input of plant residues (t C ha^{-1}), Average monthly mean air temperature (^{0}C), Clay content of the soil (%), DPM/RPM ratio, Soil cover, Depth of soil layer sampled.

In Model Structure, there arefour active compartments Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO) and Humified Organic Matter (HUM). Both DPM and RPM decompose to form CO2, BIO and HUM.The proportion that goes to CO_2 and to BIO + HUM is determined by the clay content of the soil. The BIO + HUM is then split into 46% BIO and 54% HUM. BIO and HUM both decompose to form more CO_2, BIO and HUM.

Decomposition of an active compartment

The active compartment contains Y t C ha^{-1}, these declines to Y e^{-abckt}t C ha^{-1} at the end of the month.

Where *a* is the rate modifying factor for temperature

b is the rate modifying factor for moisture

c is the soil cover rate modifying factor

k is the decomposition rate constant for that compartment

t is 1 / 12, since *k* is based on a yearly decomposition rate.

So, Y (1 - e^{-abckt}) is the amount of the material in a compartment that decomposes in a particular month.

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2. CENTURY Model

The CENTURY model is a site-specific complex model used to simulate C, N, P, and S dynamics in the soil (Smith *et al*., 2009). It has been primarily developed for grassland and later expanded to the agricultural system and forest system. The model includes several sub-models such as the SOM sub-model, water budget, and plant production sub-model.

CONCLUSION

Soil quality assessment is important to assess the sustainability of soils under the present ecosystem as well as to forecast the resilience of the ecosystem under the environmental constraints. Several physical, chemical, and biological indicators are used to assess soil quality from a crop production perspective. Among these indicators, biological indicators are considered as most sensitive to change. SQI methods are widely being used to assess soil quality at present as they are easy to use and quantitatively flexible. The geospatial modeling approach involving modeling change in SOC and other soil parameters approaches have been attempted by various researchers.

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