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Research Article

THE ROLE OF SOIL QUALITY IN TODAY'S WORLD

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ABSTRACT
Soil quality has evolved as an educational and assessment tool for evaluating relative sustainability of soil resource management practices and guiding land-use decisions. Soil quality has found a very precious and special status in today's agriculture and especially in sustainable development and neglecting it enters severe damages to the environment around us. Those measurable soil properties that affect the capacity of soil to empower product is called soil quality index. Some of the characteristics include organic matter, aggregates, pH, EC, nitrate nitrogen and bulk density. The aggregated quality index or Nutritional Quality Index is two evaluation models in arid and semiarid regions. Using these indicators of soil quality study is needed to solve the problems of soil. To fix any problem, the study of indices and soil characteristics is needed. Salinity, Sodium and poorly draining are some of the soil problems that were examined to solve soil problems and its probable cause were examined.

Keywords: *Soil Quality Index, Assessment Models, the Soil Problems*

INTRODUCTION
Soil quality is defined on sustainable agriculture and protecting the health of the environment as: The concept of soil quality as the capacity for a certain type of soil for application in natural and managed ecosystems is expressed (Karlen *et al.,* 2001).

Soil quality as a specific concept emerged rapidly during the decade of the 1990s, evolving as an outcome of increased emphasis on sustainable land use. A greater awareness of trade-offs associated with increasing world demands for food, feed, and fiber, public demand for environmental protection, and decreasing supplies of nonrenewable energy and mineral resources (Doran et al., 1996) provided the impetus for questioning the sustainability of current soil management decisions (Pesek, 1994). Interest in and adoption of the soil quality concept as a tool for assessing the effects of land-use and soil management decisions on the sustainability of soil, water, and air resources were most rapid among natural resource conservationists, farmers, land managers, ecologists, and various sustainable-agriculture groups throughout the world.

Periodic assessment is needed to identify the condition of soil resources at all scales – within a lawn, field, farm, watershed, county, state, nation or the world.

Because historically, humankind has neglected its soil resources more than once – often ending in failure of the dominant society and culture (Lowdermilk, 1953; Hillel, 1991). Even after more than 1,000 years of abandonment, soils of the Tikal rain forest have not recovered from the Maya occupation (Olson, 1981). Similarly, the catastrophic land management failures of the 1930's began with ignorance of the Great Plains' soil resource, which was described as "indestructible and immutable" in the 1909 Bureau of Soils Bulletin 55 (Whitney, 1909).

Implementation of a wheat (Triticum aestivum L.) – fallow cropping system and use of intensive tillage throughout the Great Plains contributed to the "Dust Bowl" that fostered Hugh Bennett's 1933 indictment of Americans as "the great destroyers of land" (Baumhardt, 2003).

Despite this well-documented history, degradation of the earth's soil resources is still among the most serious and widespread threat to humankind.

With very little effort, we can find gullies cutting large fields into small parcels, road ditches that have to be cleaned out, silt-laden streams, lakes being choked by sediment, and windstorms with blowing soil darkening western skies and cutting off young cotton (Gossypium spp.), wheat or soybean [Glycine max (L.) Merr.] Plants. These are such visible signs of soil degradation that it is no surprise tolerable soil loss or T, defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained, became the primary tool used to assess sustainability of soil resources. However, focusing on T, using the Revised Universal Soil Loss Equation (RUSLE2) (Lightle, 2007) or the Wind Erosion Equation (WEQ) (Woodruff and Siddoway, 1965; Sporcic *et al.,* 1998) alone or in combination, fall short as assessments for estimating impacts of management on the long-term sustainability of soil resources. These tools address only one aspect of soil degradation – erosion. Soils can also be degraded by salinity, sodicity, excess water, compaction, heavy metals, acidification, and loss of nutrients and organic matter. Since these degraded conditions exist on millions of hectares worldwide (Oldeman, 1994), it is essential that more robust assessment tools be developed.

Current efforts to define soil quality/health and develop multi-factor assessment protocols can be traced to publications from the 1970s (Alexander, 1971; Warkentin and Fletcher, 1977). This coincided with increased emphasis on “Sustainable Agriculture” during the mid- to late 1980s (e.g. NRC, 1989) that brought public attention to the increasing degradation of soil resources and the implications for environmental health. In Canada, the Canadian Soil Quality Evaluation Program was one of the first national efforts focused specifically on soil quality assessment. As discussion of and interest in the concepts of soil quality and soil health spread worldwide (Karlen *et al.,* 1997; 2001), many questions were raised regarding the sustainability of current soil and crop management decisions (Pesek, 1994). Several ideas for assessment evolved following publication of quantitative formula for assessing soil quality (Larson and Pierce, 1991) and efforts to relate changes in various indicators to soil management practices (e.g. Karlen *et al.,* 1994a,b).

Interest in soil quality among natural resource conservationists, scientists, farmers and policymakers increased even more after the U.S. National Academy of Sciences published the book entitled Soil and Water Quality: An Agenda for Agriculture (NRC, 1993). This report stated that more holistic research was needed to ensure soil resources were sustained, water quality was protected, and money invested in conservation was well spent.

Among the responses to those challenges were the reorganization of the USDA-Soil Conservation Service (SCS) to the USDA-Natural Resources Conservation Service (NRCS), creation of several Institutes including the USDA-Soil Quality Institute, development of user-oriented soil quality scorecards and test kits (Romig *et al.,* 1996; Sarrantonio *et al.,* 1996), and several symposia (e.g. Doran *et al.,* 1994; Doran and Jones, 1996) that defined soil quality, identified critical soil functions, and proposed applicable assessment methods (Doran and Parkin, 1994).

Soil quality as a factor which is influenced by Inherent features and soil management is intended and will be assessed by determining soil quality indicators (Doran and Parkin, 1994). Those measurable soil properties that affect the capacity of the soil for crop production capabilities are called soil quality indicatorsc (Arshad, and Martin, 2002). Soil quality indicators are defined as processes and characteristics of the soils that are susceptible to soil use changes (Aparicio and Costa, 2007). These features are important for a simple assessment of soil quality. Soil quality is different in different geographical regions because of differences in climate, topography, parent material, vegetation and land use. Different characteristics of the soil are considered as indicators of soil quality. A soil quality index should have the following features:

A. Including environmental process
B. Including physical, chemical and biological characteristics of soil
C. Sensitive to environmental changes and management
D. Be measurable, accessible and have quantitative processing

Some Physical, Chemical and Biological Properties for Determining Soil Quality Indicators
Soil Organic Matter

because of its important roles for crop production including the biological functions associated with growth and support of beneficial microorganisms and micro-, meso-, and macro-fauna (e.g. earthworms); chemical functions associated with cycling and supplying essential plant nutrients (especially N, P, and S); and physical functions associated with soil structure, tilth, surface crusting, runoff, and water as well as air entry, retention and transmission (Sikora and Stott, 1996; Stevenson, 1986). Soil organic matter status is influenced by management practices such as tillage intensity, crop residue management, and cropping intensity and diversity (Varvel, 1994).

Soil Aggregation which reflects the arrangement of the primary sand, silt and clay-sized particles into structural units defined as peds. Within their inherent limits (i.e. sands will always have fewer aggregates and lower aggregate stability than loam, clay loam, or clay soils), soils with an optimum level of aggregation will be more resistant to surface sealing, thus allowing more rapid water and air penetration. Soils with good aggregation will generally provide better soil – seed contact, which will result in more rapid transmission of water to the seed, quicker germination, and generally better and more uniform establishment of the desired crop. Soil aggregation is primarily influenced by tillage intensity and residue management (Tisdall and Oades, 1982).

pH, Because of its effect on nutrient availability (e.g. P amd Zn) and both toxicities (e.g. Al or Mn) and deficiencies (e.g. Mn, Fe, and Zn), ammonification and nitrification processes, microbial habitat, and plant root growth and development. Soil pH is also a good indicator of the attention being given to effects of management practices such as the use of ammonium fertilizers, liming, and animal manure application.

Electrical Conductivity (EC) has generally been associated with determining soil salinity, but it can also serve as a measure of soluble nutrients – both cations and anions (Smith and Doran, 1996) within a specific range, EC can be used to indicate the status of nutrient availability for plants, with the low end indicating nutrient poor soil that is structurally unstable and disperses readily. High EC values often reflect poor plant growth conditions and the potential for salinity problems.

Salinity and **SAR** are generally more important in arid or semi-arid areas where excessive transpiration can result in a buildup of salts in the near surface horizons. They can also help detect the presence of seeps where water that infiltrated at higher landscape positions has flowed along impervious layers and now intersects the surface once again.

Plant Available P is important because of its role in supporting plant growth, but must also be monitored to ensure that it does not become an environmental hazard if surface runoff occurs (Sharpley *et al.*, 1996).

Management practices can influence available P through fertilizer and animal manure applications as well as by maintaining a near neutral pH.

Nitrate-N (NO3-N) reflects the residual effects of a many practices including crop rotation, fertilization strategies, and use of animal manure. It provides insight regarding the potential for leaching and contamination of groundwater or surface water sources and for release of nitrous oxides (NOx) emissions (Rice *et al.*, 1996; Allan and Killorn, 1996).

Microbial Biomass Carbon provides a measure of the biological activity within a soil. It reflects nutrient cycling processes that are essential for meeting crop growth. It is also influenced by management practices such as tillage intensity, crop type (annuals versus perennials) and crop residue management strategies.

Bulk Density (BD) defined as the mass of dry soil per unit volume is an important soil quality indicator because of its potential effects on plant root development, exploration, and thus the volume of soil that each plant can draw upon to meet their water and nutrient needs. Management practices such as tillage, wheel-traffic patterns, timing of field operations (because of the interaction with soil water content) and residue management influence bulk density (Arshad *et al.*, 1996).

The next set of scoring curves being developed for the SMAF are for water-filled pore space as an indicator of the type of microbial functioning to expect (aerobes vs anaerobes), soil-test K, and β-glucosidase activity. Many other potential indicators have been suggested (Karlen *et al.*, 2001) and for some scoring functions will be developed and incorporated into future versions of the SMAF.

Evaluation Models

Some quantitative models have been proposed to determine soil quality; these models consider the impact of a set of soil characteristics and provide a small amount of soil quality. Among these high performance models in arid and semi-arid areas are cumulative quality index and Nutritional Quality Index which are calculated using two sets of soil properties, including the entire data set (TDS) and minimum data sets (MDS). Soil Stability Index and cumulative ranking are the other two models that are used based on physical stability against erosion.

For the selection of the minimum data set (MDS), due to the method of principal component analysis (PCA) in selection of MDS, this method is used. PCA method selects the attributes that have the greatest impact on soil quality to reduce the volume of data. According to the method presented by Andrews and colleagues (Andrews *et al.*, 2002) and Guartz and Colleagues (Govaerts *et al.*, 2006) to select the MDS, the main component with a value greater than one are selected as MDS. Finally, using the following equation, for each sample IQI and NQI models are calculated using TDS and MDS.

$$IQI = \sum_{i=1}^{n} W_i \; N_i$$

Where WI is the belonged weights to soil properties, Ni is the belonged score to each feature and n is the number of desired features. To determine attributes weights (Wi), the contribution of each feature (COM) is calculated by analysis factor of FA sing SAS statistical software (Shukla *et al.*, 2006). The relative contribution of each feature to the total amount of contributions is considered as the weight of each feature to calculate the soil quality index. Given the characteristics of the various units are to offer them in terms of overall value, it must be dimensionless. Fuzzy membership functions are used for this purpose. Thus the range of value of the quality of the soil is most desirable, the membership amount is one and the range with the lowest quality is zero. Thus a function is obtained by using the appropriate attribute values between zero (least favorable for soil quality) and a (most favorable for soil quality) are scored. Using these features, ratings and reviews for each soil sample were used in relationships.

$$NQI = \sqrt{\frac{P_{ave}^2 + P_{min}^2}{2}} \times \frac{n-1}{n}$$

In which pave is the average score of the selected features in each soil sample, p_{min} is the minimum score on the features selected for each sample and n is the index number of the desired features.

To determine soil stability index (SI) in each sample, Multi-threshold characteristics of the soil features are defined in terms of soil stability. By calculating the arithmetic mean values, soil stability index (SI) is determined (Govaerts *et al.*, 2006).

CR index in each sample is determined by the method of Shukla *et al.*, method (Shukla *et al.*, 2004). For this purpose, 9 properties of soil, including pH, EC, mean weight diameter (MWD), the percentage of aggregates stable in water (WSA), water holding capacity (WHC), soil texture, bulk density, total porosity and percentage of organic carbon is considered. Then based on provided critical range, each soil characteristic is assigned the score of 1-5 so that a score of 1 to 5, the lowest score of the highest quality features and quality of the property was assigned. Finally, a total of nine scores for each soil characteristics, as measured by the cumulative ranking (CR) was considered its soil.

Calculating the Index is done using the following Physical and Chemical Properties, including two Stages

A- Determining the minimum set of data using experts' opinion

When an ecosystem or soil characteristics is not possible, most researchers consider the soil characteristics or indicators needed to measure soil quality or feature. Minimum set of data should have all the features relative to one area or cultivating system. Each Minimum set of data is appropriate for a specific region or soil map unit (soil type) and includes only the features relative to soil type, cropping system, land uses for the area to be measured.

Collecting at least class of partial information helps to identify regional indicators and the indicators selected to measure the link between plant and soil and significant features of the area.

The minimum set of data is a set of physical characteristics, chemical and biological soil surface that is determined by a group of Soil Science experts in order to calculate the soil quality index is determined (Marzaioli *et al.,* 2010; Doran and Parkin, 1994).

B- Rating each data set using linear equations of mathematical

At this stage, the characteristics of Minimum set of data are placed in two categories of A: more is better, B **-** less is better. The first group includes those characteristics that high levels of the desired effect on the soil instead of the leaves (including total nitrogen, moisture, etc.) The second group encompasses variables are the lowest they will have a positive impact on the soil (e.g. bulk density). Thus, the extent of this attribute is equal to or less than the specified range desired features and as part of the first group to be more, shall belong to the second group. The points corresponding to each of the variables used in these two groups are calculated by the following equations (Andrews *et al.,* 2002).

$$\text{Q index} = \left(\sum s_i / n\right) \times 10$$

$$\text{second group} = \frac{\text{lowest value}}{\text{value of each iteration}}$$

$$\text{first group} = \frac{\text{value of each iteration}}{\text{highest value}}$$

Integration points are calculated into an overall index as indicators of soil quality (Andrews *et al.,* 2002; Marzaioli *et al.,* 2010)

si = Scores given to each indicator

n= total number of indicators

Using these indicators and Quality of soil is needed to resolve a problem of soil. To fix the problem Need to review the criteria and characteristics of the soil is the following are some of the problems and characteristics of the soil to overcome this problem should be investigated and the likely cause of the problem is given:

Problem: **Compaction**. Indicators to test: Bulk density, Penetration, resistance, Porosity, Root growth patterns. Possible Reason for Low Ranking: Working wet soil, Excess traffic, Heavy machinery, repeated tillage at same depth, Excess animal traffic, Poor aggregation, Low organic matter

Problem: **Crop disease**. Indicators to test: Plant health, Crop vigor, Yield. Possible Reason for Low Ranking: Compacted layers, saturated soil, Soil pathogen problems, Nutrient deficiencies or unbalance
Low organic matter, Monoculture, Low biological diversity

Problem: **Crusting**. Indicators to test: Aggregate stability, Slake test, Observations. Possible Reason for Low Ranking: Excess sodium, Low organic matter, Low residues

Problem: **Drainage**. Indicators to test: Infiltration rate, Hydraulic conduct. Possible Reason for Low Ranking: Tillage pan, High water table, Poor soil structure

Problem: **Soil life**. Indicators to test: Earthworms, Soil respiration, Microbial biomass, Pitfall trapping. Possible Reason for Low Ranking: Low organic matter, Low residues, Excess pesticides or fertilizers,
Excess tillage, Poor aeration

Problem: **Salinity**. Indicators to test: Electrical conductivity, Observe white crust. Possible Reason for Low Ranking: Saline seeps, Saline irrigation water/well, Shallow water table, Poor drainage, Excess evaporation

Problem: **Erosion**. Indicators to test: Observe rills, gullies, Topsoil depth, and Aggregate stability. Possible Reason for Low Ranking: Lack of cover and residue, Low organic matter, Poor aggregation, Tillage pan or compacted layer, Tillage practices that move soil, down slope, Excessive tillage, And Intensive Crop Rotation

Problem: **Infiltration**. Indicators to test: Infiltration rate, Aggregate stability, Soil structure. Possible Reason for Low Ranking: Compaction, Surface crusting, Plow pan, Poor soil structure/aggregation, Excess sodium

Problem: **Organic matter/residue**. Indicators to test: Organic carbon, Percent residues. Possible Reason for Low Ranking: Excess tillage, Residue burned off, Low residue crops, too much fallow, insufficient additions of crop residue

Problem: **Soil pH**. Possible Reason for Low Ranking: Use of ammonium fertilizers, No liming, poor drainage

Problem: **Sodium**. Indicators to test: Soil structure, Soil pH, SAR. Possible Reason for Low Ranking: Seeps, Shallow water table, Low calcium irrigation water, Poor drainage

Problem: **Tilth/soil stability**. Indicators to test: Aggregate stability, Slake test, Structure index. Possible Reason for Low Ranking: Low residues, Low organic matter, Excess tillage, Fallow Compaction

Problem: **Soil fertility**. Indicators to test: Organic carbon, Soil pH, Soil fertility test, CEC. Possible Reason for Low Ranking: Nutrient imbalances (deficiencies or excesses), Poor drainage, Poor or limited soil microbial activity, incorrect pH, Low organic matter

Problem: **Available water holding capacity**. Indicators to test: Organic carbon, Water content at field capacity, Porosity. Possible Reason for Low Ranking: Compaction, Low organic matter, Excessive drainage, Low aggregation, Low biological activity

Conclusion

Permanent ability of soil as a living system in the ecosystem under different operation so as to maintain the biological productivity, Can improve air and water quality and Also supplier of human health, animals and plants. Certainly in the near future, more indicators will be analyzed and knowing these measures can help to maintain soil and the higher-order environment and is an essential step towards sustainable development.

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