Soil Quality – To Regulate or to Manage?

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Abstract: The concept of soil quality was conceived in the early 1990s as a parallel to those of air and water quality in response to concerns about soil 'health,' sustainability and environmentally 'friendly' crop production. The concept has the potential to be used by researchers to link soil research issues to broader environmental issues when applying for funds.

However, unlike air and water, soils have no defined 'pure' state against which measures can be taken and comparisons made. The physical, chemical and biological composition of soils varies widely and no single attribute or soil type can be established as a standard. The choice of appropriate soil properties and their standards depends on the use to which the soil is put.

We suggest concentrating on quality management of the soil, rather than managing generically-chosen soil properties, collectively called soil 'quality'. Quality management puts the onus on managers to use the technical tools that are readily available to manage soils and landscapes, and on scientists to develop new tools.

INTRODUCTION

The soil quality paradigm was developed in temperate areas of USA and western industrialised countries (Sanchez *et al.*, 2003) to raise awareness of potential environmental damage caused by high input agriculture (Doran *et al.*, 1994). The idea was to facilitate government regulation of what can or cannot be done by land managers by establishing soil property standards. Such regulation may use data from groups such as the Soil Quality Institute of the USDA's Natural Resources Conservation Service. The Institute website (http://soils.usda.gov/sqi/sqw.html) describes its purpose – 'to protect and improve long-term agricultural productivity, water quality and habitats of all organisms including people.' Some soil properties (indicators), such as soil organic matter are given greater emphasis than others. Singer and Ewing (2000) present a balanced and broad overview of the soil quality concept.

Sanchez *et al.* (2003) point out that concern with nutrient pollution drove the development of the soil quality concept in the temperate regions, but in the tropics the main concerns are food insecurity, rural poverty and ecosystem degradation. So, differing issues or concerns require different approaches to soil management.

A significant difficulty with the soil quality concept is that different parameters and standards are needed for each crop, land use and type of management. Some parameters may not be quantitative, and so would require qualitative assessment and the risk of evaluator subjectivity. Another difficulty is that some regulators with biased views may unduly weight certain parameters for political or other purposes. Thus there is a risk that not all standards or situations would be implemented with equal scientific rigour. Also, researchers may be tempted to seek funds by shifting their research emphasis to an environmental bias rather than a productivity bias.

Some have favoured structuring the soil quality concept to parallel air and water quality regulatory paradigms. Sojka and Upchurch (1999) argued that although air quality and water quality are ingrained in the scientific and general community, it does not necessarily follow that soil quality is a logical extension. Quantitative standards for the chemical, physical and biological properties of air and water can be determined and have been legislated in several countries. Peoples' concerns for the environment, awareness of the effects of contaminants and pollution of the air and water, the establishment of Environmental Protection Acts in many countries and the, 1992 Earth Summit Agreements (United Nations Division for Sustainable Development,, 1992) have driven the soil quality agenda. However, soil is vastly more complex than air or water. These complexities include varying proportions of sand, silt, various clay minerals, air, water, salts, decomposing rocks and organic matter, plus living plant and animal organisms from single cells to complex fauna, all continuously interacting with each other and the surrounding environment.

Hence soil quality is not a simple parallel to air and water quality. This paper explores important issues and notes some useful aspects of the soil quality concept and asks questions to encourage debate.

STRENGTH OF THE CONCEPT

Several facets of the soil quality paradigm are useful. The key suggestion is the measurement of soil properties and the encouragement to periodically monitor them, so that changes are recorded. Then actions can be taken to address any adverse changes before they affect productivity or before other downstream resources or adverse environmental effects occur to reduce the options for future use.

For success, standards need to be set and goals established to measure progress. The ultimate goal would be to maintain or improve important soil and landscape attributes through best management practices. If soil managers control the relevant parameters and goals for assessing the soil's productive capacity, there is a good chance for improved sustainability.

WEAKNESS OF THE CONCEPT

There are several major weaknesses related to facets as broadly ranging as the difficulty of semantics and fundamental scientific implementation. These have been discussed in significant detail by Sojka and Upchurch (1999); Singer and Sojka (2001); Sojka *et al.* (2003) and Letey *et al.* (2003). To begin with, the vocabulary is nebulous and may confuse many people. Terms like 'quality' and 'value' have many context-dependent meanings. Thus, according to Karlen *et al.* (1997), policy makers, regulators and land managers can interpret standards differently than was intended by those setting the standards. The word 'function' is also confusing when related to soil (Letey *et al.*, 2003). The soil has many functions, but it cannot 'manage' these without human intervention. The 'quality' of management as much as or more than the 'quality' of the soil determines its productivity or other desired outcomes.

Another concern is that if soil quality becomes enshrined in legislation, it would be difficult to regulate or police many aspects, such as soil chemical and physical properties, respiration rate, etc. But perhaps a greater weakness is that variability in geology, parent material, climate, season, crop and economics make it impossible to set uniform standards and costly or impractical to set standards for each situation. Furthermore, some soil properties, e.g. soil structure, biological activity, drainage, and even soil texture, may be subjectively assessed, allowing personal bias to influence evaluations. Such biases can be amplified when several parameters are subjectively weighted and combined to give a soil quality 'score'.

APPROACHES TO QUALITY SOIL MANAGMENT

Letey *et al.* (2003) and Sanchez *et al.* (2003) noted some positive facets of the soil quality concept that are useful for promoting sustainable soil management. Letey *et al.* (2003) suggest the definition of soil quality include reference to the soil's specific intended use, elimination of terms like 'capacity' and emphasis on the management of the resource properties. As an example, they suggest that more detail of proposed use is required. The crop species and whether it is rain-grown or irrigated should be considered, rather than the more general term, cropping, when assessing the soil's suitability for the enterprise. They also comment that good managers utilise all available technical information in managing their soil and crops. Sanchez *et al.* (2003) suggest that soil quality 'be viewed within a broader context, as a component of an integrated natural resource management framework'. They describe the fourth version of the 'fertility capability soil classification', that was developed over the past 25 years. This takes account of basic soil properties such as surface and subsoil texture at one level and 17 modifiers at the second level. Examples of modifiers are waterlogging, aerobic condition, soil temperature, slope, aluminium toxicity, salinity, P fixation, buffering capacity and organic carbon. Specific examples of approaches to the management of soil quality already being used are described below.

Soil health cards and workbooks

In Australia, the Northern Rivers Soil Health Card came from a project initiative of the Tuckombil Landcare Inc., in partnership with NSW Agriculture and the Natural Heritage Trust (Anon, undated). This bottom-up (farmer) development was completely voluntary and it arose through a series of workshops held at the Wollongbar TAFE (College of Technical and Further Education).

Farmers are given simple instructions for making such items as a quadrat, a penetrometer and an infiltrometer and advised to purchase a pH test kit, and other items to allow them to measure some key soil properties. The measurements are easy to make and forms are provided for recording soil resistance (penetrometer), infiltration, root development, soil structure, slaking, pH, ground cover, leaf colour, earthworms and other soil animals, so changes can be monitored. The farmers of the north coast region of NSW considered these properties the most important, to provide guidance towards more sustainable management. If the score for any indicator is low, farmers are advised to discuss options for improvement of that attribute with a farm adviser or NSW Agriculture Extension Officer. This Soil Health Card is not intended to replace existing standard soil chemical analyses or other testing, but is intended to provide a complementary tool for the farmer to use, to increase his/her understanding of the soils and to increase sustainability. Health cards are available at the web site: http://www.lis.net.au/~tuckland

The Bureau of Sugar Experiment Stations (BSES) in Queensland has developed a self-assessment workbook, COMPASS – Combining Profitability And Sustainability in Sugar, to assist sugar cane farmers develop better farming practices, (Azzopardi, 2001). The section on nutrition and fertiliser use concentrates on advice that ensures the crop's nutritional needs are met in a sustainable manner. Other sections related to soil management include soil health, irrigation and drainage.

Codes of practice

In Australia, industries such as sugar cane, (Azzopardi, 2002), fruit and vegetables, (Anon, 1998), cotton, (Williams and Williams, 2000), forestry, (Forest Practices Board, 2000), fertiliser spreaders and suppliers, (FIFA, 2001), agricultural advisers and consultants have developed their own codes of practice. Most of these codes of practice provide soil and nutrient (fertiliser) advice that includes soil testing, recording fertiliser rates, methods and timing of application, general soil and irrigation management, all of which are directed towards sustaining the soil resource with environmental responsibility.

Good agricultural practice

In Europe, an organisation representing leading retailers, EUREP, has established a protocol that provides guidelines for demonstrating to customers a company's commitment to good agricultural practice, (hence EUREPGAP). It provides a framework by which practices in the fresh produce supply chain can be verified. It incorporates integrated pest and crop management principles and a certification scheme for verification (www.eurep.org/FoodPlus).

Ecosystem protection

Society in general recognises the need to protect ecosystems such as the Great Barrier Reef off the coast of Queensland, wetland areas along Australia's coastline, alpine wilderness areas, native forests and native flora and fauna. Hence land managers in those farming areas that may influence such sensitive ecosystems are now aware of those practices that may adversely affect the ecosystem. They are advised on the best practices for their situations.

Choosing soil quality indicators: Lessons from the forest industry

Australia and 11 other countries that collectively contain 90% of the world's temperate and boreal forests commenced a process in, 1992 at the United Nations Congress on Environment and Development, Rio de Janiero, to define criteria and indicators for sustainable forest management. It is known as the 'Montreal Process', because the first meeting on this issue was held in Montreal in, 1993. Australia set up a national group to oversee the process. In, 1998, they arrived at a list of indicators and categorised them for implementation at a regional level (Montreal Process Implementation Group, 1998), which contributed to an international conference that evaluated criteria and indicators of sustainability (Raison *et al.*, 2001).

Eight of the 67 indicators specifically address soil and water issues. All 67 were ranked for their implementation potential: A = 'Largely implementable now', B = 'Require some development', C = 'Require longer-term R&D'. All soil and water indicators fell into category C, including indicators related to soil erosion, organic matter and bulk density. For example, Raison and Rab (2001) and Bauhus *et al.* (2002) documented the difficulties of using soil indicators. However, an interim indicator was developed for soil erosion that fell into category A: ***Area and per cent of forestland systematically assessed for soil erosion hazard, and for which site varying, scientifically based measures to protect soil and water values are implemented.***

This interim indicator is useful because it has encouraged the use of Government-based codes of forest practice that are assessable, legally binding, and achieve useful improvements in the protection of soil and water. These codes of practice are updated as new information about the interactions among forest management, soil and water become available. In Australia, the codes are supported by the major stakeholders, i.e. government, public and forest industry. These codes form the basis for arrangements between federal and state governments, e.g. Regional Forest Agreements, and they are an important part of forestry certification standards, e.g. the Australian Forestry Standard (Standards Australia, 2003).

Several important messages can be gleaned from this process. Firstly, there was no attempt to derive an overall index for sustainability in any of the standards and agreements. Secondly, generalised ratings of soil and water quality were useful in only management- and ecosystem-specific contexts. Thirdly, we still need long-term, case study research (well-designed experiments in representative ecosystems) to define and evaluate the usefulness of suggested indicators of soil quality, because we do not have the knowledge base to define the links between all the salient ecosystem processes in the numerous types of environments in which we wish to use the indicators. Fourthly, we should not forget that we wish to improve on-ground practices in the short-term, despite our limited knowledge, and that establishing and implementing industry codes of practice are likely to achieve this.

SOME RELEVANT QUESTIONS AND FINAL COMMENTS

In developing indicators of soil quality in particular agro-ecosystems, the following questions should be considered. Which properties are the important ones? Who decides which properties are the important ones? Who sets the standards for each property? Who regulates adherence to the standards? Who decides the penalties for non-compliance and who administers them?

In Australia, the rationale for emphasising proven management of the soil and land over arbitrary indexing is embodied in the naming of its primary land management program, Landcare (note, it is not Landquality!). We suggest that the soil quality concept be changed so that the emphasis is on quality management of the soil, rather than management of some subjectively chosen soil properties, lumped together and called 'quality'. Quality management of the soil puts the onus on the manager to use the soil and the landscape by taking quality advice and using the best resources and technical tools available and on scientists to develop and evaluate new tools and techniques for use as soil indicators.

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