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Главные редакторы: Виктор Г. Сычёв и Лотар Мюллер

НОВЫЕ МЕТОДЫ И РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЛАНДШАФТОВ В ЕВРОПЕ, ЦЕНТРАЛЬНОЙ АЗИИ И СИБИРИ

Монография в 5 томах

Том I Ландшафты в XXI веке: анализ состояния, основные процессы и концепции исследований

В содружестве с Академией почвенного плодородия Митчерлиха (МИТАК), Паулиненауэ, Германия

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Vol. I Landscapes in the 21th Century: Status Analyses, Basic Processes and Research Concepts

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Монография содержит информацию о самых современных методологиях и результатах в ландшафтных исследованиях. Она может быть использована в качестве руководства для исследователей, преподавателей, студентов и всех, кого интересует тема ландшафтной науки и смежных дисциплин. Монография является особо ценной информационной базой для лиц, принимающих решения на различных уровнях, от местных до международных органов по принятию решений. Приведенная в монографии информация представляет собой современный уровень ландшафтной науки в очень краткой форме.

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Main editors: Lothar Mueller (Leibniz Centre for Agricultural Landscape Research, Muencheberg, Germany) and Viktor G. Sychev (All-Russian Research Institute of Agrochemistry named after D.N. Pryanishnikov, Moscow, Russia)

This monograph shall inform you about up to date methodologies and recent results in landscape research. It is intended as a guide for researchers, teachers, students, decision makers, stakeholders interested in the topic of landscape science and related disciplines. It provides information basis for decision makers at various levels, from local up to international decision bodies, representing the top level of landscape science in a very short form.

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Chapter I/39: MEASURING THE EFFECTS OF FARMING SYSTEMS ON PHYSICAL, CHEMICAL AND MICROBIOLOGICAL PARAMETERS OF SOIL QUALITY
Глава I/39: Изучение влияния систем земледелия на физические, химические и микробиологические параметры качества почв

Anna M. Gajda*; Karolina Furtak

DOI 10.25680/1838.2018.31.13.039
*Email: ag@iung.pulawy.pl
Department of Agricultural Microbiology, Institute of Soil Science and Plant Cultivation - State Research Institute, Czartoryskich 8, 24-100 Puławy, Poland.

ABSTRACT. At present times, with the growing population and increased demand for food, intensive farming systems are commonly used to increase yields. However, the agricultural management causes a changes in soil environment, especially in diversity and activity of microbial communities. Microbial biomass, potentially mineralizable nitrogen, and enzymes activity (dehydrogenases, phosphatases, FDA hydrolysis) are recommended as indicators of soil quality. From physical parameters can be mentioned, among others: particle size distribution, bulk density, and soil water content. It is important to monitor the soil parameters, because the fertile and healthy soil allows to obtain good quality yields.

Резюме. В настоящее время с ростом численности населения и ростом спроса на продовольствие интенсивные системы ведения сельского хозяйства обычно используются для увеличения урожайности. Однако управление сельским хозяйством вызывает изменения в почвенной среде, особенно в области разнообразия и активности микробных сообществ. В качестве индикатора качества почвы рекомендуются микробная биомасса, потенциально минерализованный азот и активность ферментов (дегидрогеназы, фосфатазы, гидролиз FDA). Из физического параметра можно указать, среди прочего, распределение частиц по размерам, объемная плотность и содержание воды в почве. Важно следить за параметрами почвы, потому что плодородная почва позволяет получать здоровые урожаи.

KEYWORDS: agriculture, farming systems, soil quality, indicators of soil quality
Ключевые слова: Сельское хозяйство, системы земледелия, качество почвы, показатель качества почвы

INTRODUCTION

Concerns over the progressive degradation of soils and the long-term transformation of applied agricultural practices towards sustainable agriculture have contributed to the development of research on soil quality (SQ). The two most concise definitions by Karlen et al. 1997 and 2001 [32, 33] SQ defined as the soil's ability to function according to its intended use. SQ can be defined as the sustained capability of soil to accept, store and recycle water, nutrients and energy. Definition by Doran and Parkin (1994) [14] describes SQ as a function of soil within natural or converted ecosystems, maintaining plant and animal productivity, maintaining adequate water and air quality and ensuring plant, animal, human and environmental health. The quality of soil much like air or water has a profound effect on the health and productivity of an ecosystem and the environments related to it [14]. The conducted by the years research showed that defining indicators of SQ is complicated by the need to consider the multiple functions of soil in maintaining productivity and environment protection and to integrate the physical, chemical and biological soil properties that determine those functions [13, 14, 38].

SOME BIOLOGICAL INDICATORS HELPFUL IN QUANTIFYING SOIL QUALITY

The idea of soil quality deals with an integrating soil physical, chemical and biological properties.

Among the methods used to assess the quality of soil we can distinguish:

1) Physical methods: particle size distribution (PSD), evaluation of soil water retention (SWR), soil bulk density (SBD), pore size distribution (PSD), soil water content (SWC), particulate organic matter (POM);
2) Chemical methods: Determination of soil organic matter (SOM) (total organic carbon and nitrogen), soil pH, determination of extractable N, P and K, electrical conductivity of soil (EC);

3) Biological and biochemical methods: assay of the microbial biomass C and N (MBC and MBN), soil respiration (SR), potentially mineralizable nitrogen (PMN), assay of the soil enzymes activity, ***e.g.:*** dehydrogenases (DhA), acid (AcF) and alkaline (AlF) phosphatases, β- glucosidase (GdA), urease (UrA), estimation of soil microbial functional diversity (SMFD).

Strong interrelations between physical, chemical and biological properties determine SQ and soil health, and since last decade soil biological activity is considered as an integral attribute of the healthy soil environment. It should be noted that changes in physical and chemical properties affect strongly soil biological properties, ***e.g.*** soil microbial respiration. Current development of the modern research methods also allows for analysis of soil microbial communities and specifying species diversity, and determination of genetic and a functional microbial communities.

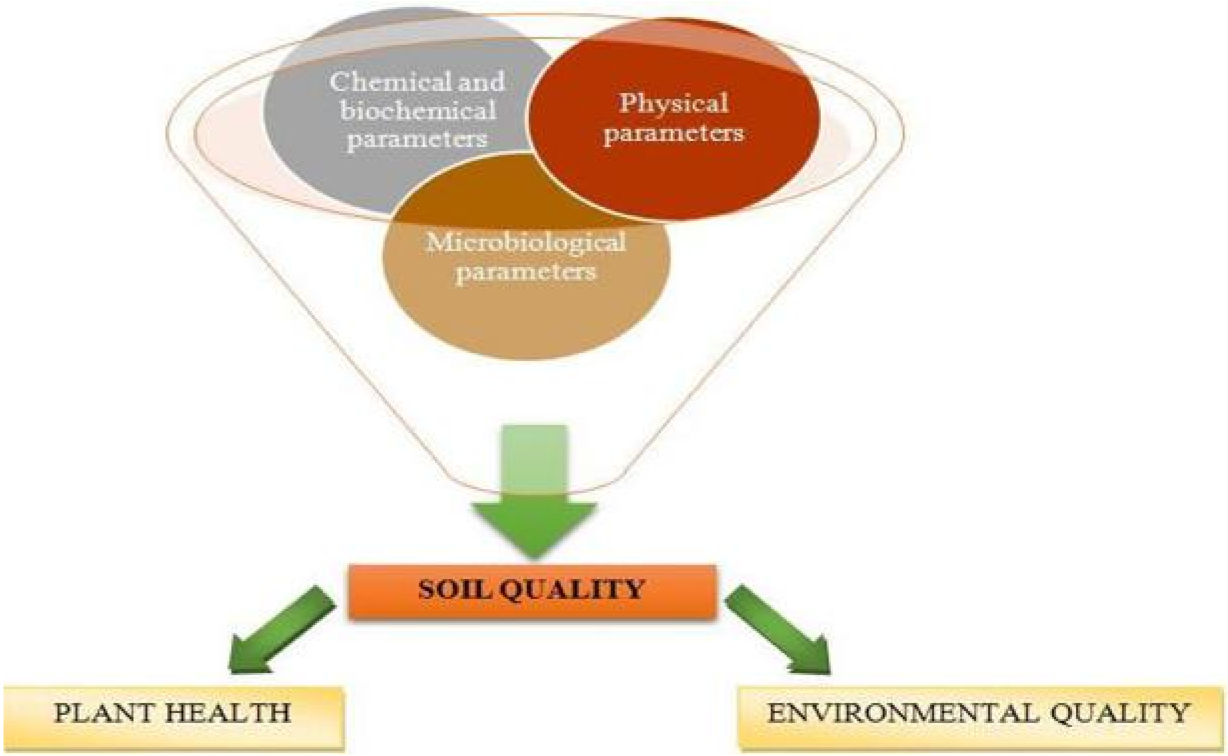

Figure 1 – The integrating soil parameters useful in determining the quality of the soil.

MICROBIAL BIOMASS C AND N

Soil microbial biomass (MB) is defined as the only one alive fraction of organic matter (OM) composed of living microorganisms inhabiting the soil [28]. The activity of soil microbial community is an important factor controlling the C turnover [41]. The soil MB content can be measured by the fumigation-extraction (F-E) and fumigation-incubation (F-I) method as given by Jenkinson and Powlson, 1976 [29, 30]. Nowadays, the more popular is the F-E method which consists in measuring the total extractable organic biomass material from freshly killed microorganisms. The results of MBC and MBN contents are usually calculated according to the formula given in Bailey et al. (2002) [4] and Brooks et al. (1985) [7], respectively.

SOIL RESPIRATION

Definition of soil respiration (SR) refers a stable rate of respiration in soil associated with the mineralization processes of organic substances in soil and estimation is on the basis of CO_2 evolution and/or O_2 consumption [11]. In our studies, the well-known method of Jenkinson and Powlson (1976) [29, 30] in a slight modification was used for assessing soil microbial respiration rate. This method as well as substrate-induced method (SIR) [5] and chamber techniques [44] are still widely used. More recent methods employ: gas chromatography (GC) for analysis of CO_2 [42, 50], dissolved organic carbon

(DOC) analysers, mass spectrometers [45], scintillation counters [51] or gas phase flow injection analysis (GPFIA) utilizing infrared detection [12].

POTENTIALLY MINERALIZABLE NITROGEN

Potentially mineralizable nitrogen (PMN) or available nitrogen (AN) is an easily determined SQ parameter [13]. PMN is regarded as a sensitive parameter to changes in soil use especially for crop production [16, 39, 43]. The most popular method for PMN estimation is the short-term (waterlogged) anaerobic incubation method developed by Waring and Bremner (1964) [52] and modified by Keeney and Bremner (1966) [35] and Keeney (1982) [34].

PARTICULATE ORGANIC MATTER

Particulate organic matter (POM) is define as a transitory fraction of soil organic matter that is intermediate in the ongoing decomposition processes between fresh plant residues and humified, stable organic matter. POM is size-defined fraction (0.053-2.0 mm) and important pool of easy available organic C in soil. Due to its dynamic nature POM has been recommended as a more sensitive to changes in soil as total organic matter. The most accurate method for assessing POM content in soil is automated dry combustion method, and/or less costly the weight loss-on-ignition (WLOI) method [8, 22].

ACTIVITY OF ENZYMES IN SOIL

Depending on the function perform in the soil metabolism, enzymes can be divided into several groups: oxidoreductases, hydrolases, lysates and ligases [49]. Many researchers present studies in which enzymatic activity has proven to be a good parameter of SQ and differentiated the effects of different tillage systems [1, 2, 18, 19, 23, 26, 48].

The most common method for determining dehydrogenase activity in soil, an important SQ parameter is Casida et al. (1964) [9] method. Friedel et al. (1994) [17] and Thalman (1968) [49] have proposed the other known methods for determining the activity of soil dehydrogenases.

Phosphatases play an important role in the soil to stimulate the conversion of organic compounds of phosphorus into inorganic phosphates [6]. The most commonly used method for phosphatase assay is the Tabatabai and Bremner (1969) [48] method with p-nitrophenyl phosphate (PNP) as a substrate. The other known and applied methods are Kuroshima and Hayano (1982) [37] method and Dick and Tabatabai (1978) [10] method.

As a good indicator of SQ β-glucosidase is recommended due to its importance in catalytic reactions on cellulose transformation releasing glucose, an important energy source for metabolically active soil microorganisms and in stabilization of organic matter resources in soil. Commonly used method for assessment β-glucosidase activity in soil is method given by Eivazi and Tabatabai (1988) [15] based on the spectrophotometrical measure of concentration of p-nitrophenyl (p-NP).

Also, urease activity has been widely used to evaluate changes in SQ related to soil tillage. That group of enzymes is involved on urea hydrolysis into CO_2 and NH_3. Widely used method for assessment of urease activity is Tabatabai and Bremner (1972) [48] method. In Poland, Zantua and Bremner (1975) [55] method in modification as described in Jezierska-Tys et al. (2004) [31] is often used. The other recommended method is Hoffmann and Teicher (1961) [27] in modification as given in Wyczółkowski and Dabek-Szreniawska (2005) [54].

THE ESTIMATION OF SOIL MICROBIAL FUNCTIONAL DIVERSITY

The widely used method for analysing microbial communities in soil is community-level physiological profiles (CLPP) [25, 36]. This method is based on checking the ability of bacterial species to utilization of different carbon sources by the use of a commercial taxonomic system BIOLOG. The BIOLOG system is based on the utilization of different carbon sources, *e.g.* popular in environmental studies ECOPlates contain 31 different carbon sources [24, 25]. The detection of the utilization of each C substrate is based on colour change which is quantified spectrophotometrically. Recently, a variety culture-independed methods based on direct isolation and analysis of nucleic acids, proteins and lipids from environmental samples have been developed for more deeply analyse of the structural and functional dependency in soil microbial communities.

MEASURING THE EFFECT OF FARMING ON SOIL QUALITY – THE RESULTS OF PREVIOUS RESEARCH

In our numerous studies we have determined the impact of the long-term different farming systems on SQ in field experiments in Poland differ in soil and climatic conditions. We indicated, in general, that conventional farming system with crop rotation as well as winter wheat and/or maize grown in monoculture (both intensive agricultural practices) have a negative influence on SQ [19, 20, 21], which is also confirmed by numerous studies, ***e.g.*** Spedding et al. (2004) [47]. In soil under reduced tillage (minimum tillage) we observed the higher values of all microbiological parameters studied, ***e.g,*** Dh activity and the soil MB content as compared to conventional tillage [20, 23]. The positive effects of reduced tillage on SQ agrees with the many researchers [40, 46, 53].

CONCLUSIONS

1. The assessment of soil quality is very important, especially for sustainable agriculture and in aspects of protection of natural environment.
2. The farming management systems are the main factors affecting changes in soil physical and chemical parameters and thus causing changes in soil biological activity.
3. There are many proven methods for assessing a soil quality.
4. The minimum data set has been proposed and recommended for assessment of soil quality.
5. A lot of research has been done on soil quality and a lot of information is being collected, but the problem is how to use this knowledge to create an universal index helpful in quick assessment of soil quality. Therefore, soil biological activity of soil should be monitored constantly on the background of changes in physical and chemical soil properties.

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