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Editorial

Soil Quality and Health to Assess Agro-Ecosystems Services

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1. Introduction

Nowadays, agricultural production systems are facing serious challenges mainly related to the climate changing, the world population growing and environmental pollution that are threatening the survival of the natural resources. The adoption of intensive agricultural practices, such as deep and frequent tillage and high mineral fertilization rate, aimed to improve crop yields, ensure food security and support human nutrition have gradually led to the degradation of the soil resource. Soil quality is commonly defined as "the capacity of a soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health" [1], while soil health was defined primarily, from an agricultural perspective, as "the soil's fitness to support crop growth without becoming degraded or otherwise harming the environment" [2]. Soils are complex and dynamic and represent an essential and non-renewable resource of the agro-ecosystems carrying out several functions, therefore, their management should be a cause of intense deliberation [3]. Indeed, soils play an important role, not only from an agronomical point of view, but also to environmental aspects as the soils filter and clean water and store carbon, contributing to the regulation of greenhouse gas (GHG) emissions, such as carbon dioxide (CO_2) and other gases. Moreover, soils are valuable tools to preserve biodiversity and, therefore, provide a series of key ecosystem services that are fundamental to our society. Every year, the adoption of intensive agricultural practices, such as deep tillage, high mineral fertilization and monoculture, may cause negative impacts on agricultural soil with loss of soil organic matter and nutrients. Moreover, additional negative effects on soil in agro-ecosystems may derive from compaction due to overgrazing or excessive passage of mechanical means, salinization resulting from high doses of mineral fertilizers and/or irrigation water with high concentrations of salts or ionic species, contamination with heavy metals and soil sealing through the infrastructure intensification. It is estimated that more of the 30% of global soils are considered degraded due to unsustainable management practices [4]. All these can be prevented by sustainable and economically feasible management techniques. Recently, the concept of sustainability has been developed to optimize the management of natural resources that should be used to satisfy the current societal needs without compromising the ability of future generations to meet their needs [5]. Similarly, soil management practices can be considered sustainable when they can maintain the provisions of ecosystem services such as: (i) provisioning of clean water, food or biomass; (ii) regulating climate; (iii) supporting biodiversity, habitats and photosynthesis; (iv) conservation of cultural heritage in archaeological areas. The mentioned ecosystem services can be provided by soil functions (e.g., water retention and filtration, nutrient cycling and soil fertility, habitats for microorganisms and mesofauna, carbon sequestration) maintenance over long periods of time under different land use [6]. Therefore, the assessment of soil quality and health, based on specific soil functions, becomes an important tool to understand the overall agro-ecosystem services.

2. A Need of Ecological Requirements for Healthy Soil: Agro-Ecosystem Functioning and Services

Any anthropic activity within the agro-ecosystems is strictly dependent on soil quality and health. Therefore, ecological attributes need to be correctly identified and assessed to support agricultural activities and protect the environment. In accordance, healthy soil should allow a natural balance or a regular succession among the soil components (chemical, physical and biological) to support plant and/or animal productivity, while preserving environmental quality. Every benefit provided by soil in the agro-ecosystems to maintain the continued capacity of biological productivity and vital living systems are recognized as ecological services. Marinari et al. [6] suggested microbial indices could be successfully used as tools for assessing soil health in terms of predictors and indicators of carbon sequestration and nitrogen availability in agro-ecosystems. As the editor of the Special Issue, entitled "Soil quality and health to assess agro-ecosystems services", agree, ecosystem services are identified according with the mankind goals and include a set of services that are perceived to be essential for the maintenance, protection, and production of agro-ecosystems. However, due to the agro-ecosystem complexity, these services are not actually expressed with well-defined measurable indicators and, therefore, require finding new ways of looking that may be used for agro-ecosystem assessment. Although soil ecological services are generally difficult to quantify, their identification should be related to a range of ecological requirements measured by the means of indicators of biological, chemical and physical characteristics, which may be acknowledged as minimum requirements to support sustainable management of agro-ecosystems. Similarly, Zhao and Wu [7] stated that the evaluation of soil health should comprehensively take soil productivity and ecological environmental effects into account in order to avoid soil overutilization as a consequence of the improvement of food production capacity to ensure national food security.

The ecosystem services are also related to the environment, soil type and management practices adopted in a given agro-ecosystem, indeed, soils differ for chemical, physical, and biological characteristics, therefore, the response to management practices tends to be different among soils as well as their resilience to agronomical practices and vulnerability to degradation that should be taken in consideration when evaluating agro-ecosystems. The meta-analysis performed by Allam and colleagues [8] highlighted the evidence of environmental and agronomical factors and how their understanding could affect the impact of these farming practices, not only on crop productivity, but also on the enhancement of soil organic matter needed for the sustainability of the farming systems in a specific region. In fact, the soil capability, defined as the intrinsic capacity of a soil to contribute to ecosystem services, emphasize the importance of static soil properties closely connected to soil taxonomy and to assess the soil response to agricultural management. In addition, some practices aimed to sustain several agro-ecosystem services at higher scales could not have the same importance to local stakeholders because of common interest. According to this statement, in developed countries where agriculture is commonly based on the continuous passes of agricultural vehicles, the findings of Moitzi et al. [9] showed cover crop cultivation with its positive ecological effects can reduce the risk of potential soil compaction and have ameliorative effects on restoring the soil structure avoiding how heavy agricultural vehicles can generate tire tracks in a field with the potential risk of subsoil compaction.

Despite soils providing a lot of agro-ecosystem services, these could be considered more and/or less relevant when compared each other's. This means that the identification of soil quality and health parameters for assessing agro-ecosystem services requires a description of the ecological risk problems and several measurable criteria necessary for an appropriate agro-ecosystem assessment in the environmental context. Recently, more attention was given to the activity and diversity of the soil microbial community, and it was observed that a large biomass and high biodiversity in surface soil up to 30 cm of soil depth may link to the degree of soil quality. However, all soil functions, such as filtration, buffering, storage, chemical/biochemical transformations, the preservation of biodiversity or potentially useful genetic material and the production of biomass should be considered and both surface and deep soil layers should be taken into account to assess sustainable soil agro-ecosystems management. In addition, Woźniak and colleagues [10] observed that some bioenergy crops could also play an ecologically fundamental role as an alternative to agri-food productions and as renewable energy sources when cultivated in abandoned soils by means of the improvement of the soil enzyme activities, microbial biomass, and metabolic diversity of microorganisms.

3. Conclusions

Ecosystem services in agricultural fields are commonly used in both research and decision-making processes, even if the agro-ecosystem services concept is still relatively young and the extension to soil-based ecosystem services is not well considered and under-represented. In fact, most activity has been carried out with provisioning and regulating services by the adoption of the physical and chemical properties of surface soil to be included in algorithms that quantify the soil-based ecosystem services, meanwhile supporting services, such as soil formation and habitat, are poorly used, probably due to the difficulties of finding easy indicators to measure these services. The complexity of soil systems makes the evaluation of soil quality and health much more challenging compared to water or air, but a wider knowledge of soil processes is probably needed, including soil properties of deeper parts of the soil profile. Indeed, the existing frameworks for soil quality assessment adopted by means of different forms of aggregation or indicators are generally too scientific and based on the context of singular disciplines or specialized only for soil expert and thus are lacking significance for public interpretation. To assess soil functions and elaborate their contribution to the functioning of the ecosystem is one approach to link soil information to ecosystem services. The evaluation of soil quality as a response to human and natural impacts allows the agricultural practice of sustainability to be comprehensively characterized. Therefore, new methods of modeling soil processes are much needed and only the assessment of the whole soil profile in transdisciplinary and cross-sectorial approaches, that includes soil systems knowledge, allows us to reach this goal.

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