Essence, Necessity, and Principle of Assessing Soil Health

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Abstract. Not many realize that soil has a role and many functions that are vital to human life and the preservation of natural and environmental resources. Accurate and practical data on soil health is needed related to aspects of productivity, support for creating a favorable environment for human life through good agro-ecosystems and ecosystems as well as the sustainability of the soil resources themselves. Soil health data is also needed as baseline for assessing whether there is improvement or decline health of the soil due to the soil use and soil management system applied. Currently in Indonesia there are no instruments to assess soil health. It is necessary to develop instrument or method to assess or measure soil health in the form of numbers so that it is easier to use to compare changes in soil health due to land or soil use and/or the land or soil management system applied.

Keywords: Soil Biological, Soil Chemical, Soil Health, Soil Health Assessment, Soil Physical

1. Introduction

Soils are the interface between aquatic, atmospheric, and terrestrial ecosystem. A better understanding of the linkages between these systems and the role that soils play those linkages has led to a new approach in assessing soils. Soil is a dynamic, living, natural body that plays many key roles in terrestrial ecosystems. The Chinese is saying that "The Soil is the mother of all things." It is a simple statement of the importance of soil to life of all living creature [1]. The function of assessing soil quality is very important for the development, performance and evaluation of sustainable land and land management systems.

Determining and predicting key management practices associated with enhanced soil, plant and human health remains an important goal of sustainable agriculture and environmental sustainability. A clearer understanding of the possible links between soil health, plants, and people is the key to improving the quality and healthfulness of foods grown in all farming systems. Soil health assessment is an important step toward understanding the potential effects of agricultural practices on crop yield, quality, human health and environmental conditions or quality. Soil health is normally viewed in terms of production, which could be biomass production [2] or productivity indices relative to fundamental soil properties; however, it recently has gained a wider focus with a global audience, as soil condition is becoming an environmental quality, human health, and political issue [3].

Currently in Indonesia there are no instruments to assess soil health. The instruments for recognizing soil and assessing soil conditions are through "Soil Type Classification" which

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provides information about the name of the soil, the type of soil and its process of formation and development of the soil and "Land Suitability Class" which provides information about the suitability of a land for certain uses and the degree of compliance accompanied by global recommendations on management and input required. Therefore, it is necessary to develop instrument or method to assess or measure soil health in the form of numbers so that it is easier to use to compare changes in soil health due to land or soil use and/or the land or soil management system applied.

Referring of natural ecosystems, the term “soil health” is not exactly equal to soil quality. Considering the time scales, soil health can describe the “potential” and “dynamic” conditions of the soil in a short period, while the soil quality can describe the “inner” and “static” conditions of the soil over longer time scales [4]. The term “soil quality” will generally be associated with a soil’s fitness for a specific use [5], while soil health is used in a broader sense to indicate the capacity of the soil to function as a vital living system [6]. Soil health focuses more on the biotic components cycling and soil fertility [7]. Finally, soil health is a vital component of natural resources in supporting human health and human welfare. As soil health mainly reflects the activity and dynamics of soil bases on soil function, it is difficult to define soil health standards. Assessment of soil health can be conducted in a variety of ways according to soil physical, chemical and biological characteristics.

2. The Component of Soil

The soil consists of organic material, inorganic mineral materials (particles of sand, silt and clay particles), water and air and living organisms such as groups of worms, insects, bacteria, fungi, algae and nematodes. In the soil, there are continual interchange of molecules and solids between solid, liquid, and harmful phases that are mediated by physical, chemical, and biological processes.

Components of soil also can be divided into soil physical, soil chemical and soil biological components. Soil physical components consist of solid ingredients (organic materials and mineral particles), water and air. Soil chemical components consists of macro elements (C, H, O, N, P, K, Ca, Mg, Na) and micro elements (Fe, Mn, Cu, Pb, Zn, B, Co, Hg, Ar, Cd, etc.). While soil biological components composed of soil microflora and microfauna, soil enzymes, soil meso and macrofauna, and soil-borne pathogens in the soil.

3. The Function of Soil and Healthy Soil

3.1 The Functions of Soil

Soils provide essential ecosystem services for supporting both human and ecosystem needs and has been under pressures resulting from the intensification and expansion of human activities. Soil has several vital functions for human life and environmental sustainability. The various functions of soil, as for land, described by Sombroek and Sims [8]are: 1) production function, 2) biotic environmental function, 3) climate-regulative function, 4) hydrologic function, 5) storage function, 6) waste and pollution control function,7) living space function, 8) archive or heritage function, and 9) connective space function.

The soil health relationship with production is only in the agricultural sector. In addition to influencing agricultural production and food, soil health also affects food health and food security. While the relationship between soil health and other sectors, such as mining, tourism, housing, industry and trade is more associated with its effects on environmental pollution related to assessment, prevention and rehabilitation to support the creation of a good

environment to support human health and human welfare and maintain environmental sustainability (see Figure 1).

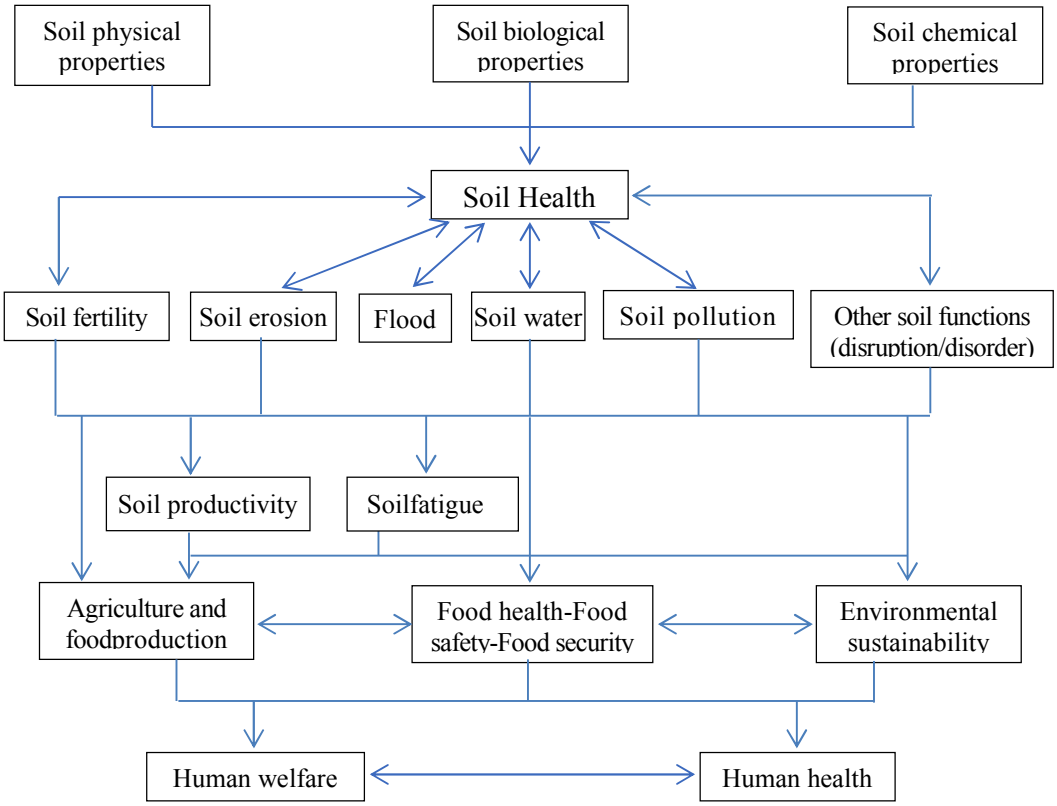

Fig1. The effect of soil health on agriculture and food production, food health and food security, and environmental sustainability

3.2 The Nature of Healthy Soil

Healthy soil does not contain elements of pollutants or contaminants that can disturb the health of humans, animals and plants and do not contribute to environmental pollution. It is characterized by being a habitat and ecosystem that is conducive to the proliferation of soil organisms (micro, meso and macro organisms). Healthy soil supports the lives of healthy and prosperous humans. In agriculture sector, healthy soil is associated with soil that has good soil quality. Healthy soil generally produces high agricultural productivity, both in terms of the quantity and quality of agricultural products. Healthy soil also has a high resilience and resistance to various disorders.

The potential for soil health to promote the resistance and resilience of plants to abiotic and biotic stress is challenging but growing area of research [9]; [10]. This research holds a lot of promise for designing farming systems that are less dependent on external inputs for maintaining productivity and resisting pests and diseases[11]. There is also growing interest in developing plant varieties that are better suited to production under biological and reduced

input forms of management, as well as varieties that contain greater concentration of minerals, vitamins, and beneficial phytochemicals for improved human health [12].

3.3 Soil Health and Organic Farming

Once it is believed that healthy soil can produce healthy food, one of the next topics that deserves to be questioned is whether organic food is healthier?. Theoretically, the answer should be "yes" because organic food are produced from organic agriculture which avoids the use of agricultural chemicals that can poison soil, flora and fauna, including food crops.

Effort to understand and link management effects to soil quality and/or soil health may lead to farming systems that have beneficial effects on both environmental and human health. Related to the management factors that influence soil health, review the literature on the links between soil and plant health, and then discuss possible link with produce quality and human health, with a focus on nutrition and plant secondary compounds, recommendations for future research, we draw heavily on organic farming systems research because the organic farming movement has been central to this debate from the beginning of the 20th century. Beside, the growing literature on organic farming systems comparisons provides unique insights into the effects of management on soil and plant health.As organic farming related to soil health is concerned, many studies have attempted to identify the motivations of organic consumers, and several review articles have summarized this work [13]; [14]; [15]. The primary reported motivations are health concerns, including nutritional quality, freshness, lack of pesticides, and food safety.

Other motivations include better taste, concerns over animal welfare, and environmental degradation. Regional variations in motivations are present: environmental concerns dominate in parts of Europe [13]; [16], whereas health benefits are the primary motivation for purchasing organic foods in North America [13]. Overall, organic consumers tend to be more concerned about potential negative health effects of pesticides and genetically modified organisms than other consumer group, and may also believe organic produce to be more nutritious [17]. Occasional consumers of organic food cite health reasons as the primary motivation. Even non purchaser of organic food frequently cite a belief that organic food is healthier [13]. Meta-analyses have shown that there are differences between organic and conventional produce that could translate to improved health outcomes for consumers, including increased antioxidants such as vitamin C and polyphenols, lower levels of cadmium (Cd) and pesticide contamination, reduced incidence of antibiotic-resistant bacteria, and less water content (greater dry matter per unit fresh weight) in organic produce [18].

4. The Importance of Soil Health Assessment

Considering how important the soil is healthy for human life and the ecosystem of the earth, information or data on soil health is needed periodically to ensure that the community always or lives on healthy soil. Humans need healthy soil to ensure the fulfillment of food, clothing, fiber, shelter and energy needs as needed (kind, quantity and quality), continuous clean and healthy water and air and healthy ecosystem conditions, free from various forms of pollution or contamination. At present the threat of pollution and soil pollution by various sources agrochemicals such as pesticides, herbicides and functions that are not environmentally friendly, industrial waste, hospitals, several types of laboratories, and so on are increasing. Other soils that also need to be assessed for the health of the soil periodically

are soils produced by reclamation processes, soils that are around the landfill or landfill, and soils in the surrounding of mining area.

For soils that have not been assessed for soil health, a soil health assessment is needed as baseline data that describes the level of soil health at that time. Furthermore, a soil health assessment is then carried out in a soil health monitoring and evaluation program to assess whether there has been a decline or improvement in soil health. Soil health assessment is also needed for planning repairs or remediation of lands that have experienced pollution, pollution or other forms of soil damage.

For this reason, a standard technique or method is needed that can be used extensively to periodically assess the health of soil in Indonesia.

5. The Principle of Soil Health Assessment

Even so, quantifying impacts on soil functions is challenging given the complexity of soil processes and the spatial and temporal variability of soil properties [19];[20]. While each soil health indicator uses a different set of indicators, certain soil parameters are frequently selected when evaluating agricultural systems. Soil organic carbon as often been considered a reliable indicator of soil health/quality as it is so closely related to other soil properties, including soil structure, nutrient availability, water holding capacity, and erosion resistance [1]; [21]; [22] as well as influencing microbial activity [23].

Other chemical properties commonly selected as indicators include soil pH, cation exchange capacity (CEC), and nutrient availability, connected to the ability of a soil to provide adequate nutrients and support plant growth [24]; [25]. Physical soil properties such Bulk Density, porosity and aggregate stability are often included as they are simple, inexpensive measurements that are related to the aeration of the soil, infiltration capacity as well as the ability to resist erosion processes [26]. Properties that are inherent to the soil, such as texture, might not work as indicators. While soil texture impacts many other facets of the soil environment from water holding capacity to CEC, it is a relatively stable measurement that is unlikely to change as a result of agricultural practices so is not particularly useful as an indicator to differentiate between management practices [27].

Biological properties are receiving increasing attention in soil health/quality indicators as these properties are more sensitive to alterations in the soil environment than physical and chemical soil properties [28]; [29]. In some cases, soil health/quality indicators have been developed that only include the biological component based on the assumption that changes in chemical and physical properties will be related to the changes in the microbial community [25]; [30].

Biological properties often included as indicators are microbial biomass, metabolic quotient, and enzyme activities [27]; [31]. While these prpperties are more sensitive to changes in agronomic practices than properties such as soil organic carbon, they often are highly variable measures with significant temporal fluctuations and spatial variability that need to be considered when using them as indicators in an soil helath/quality indicator[24], [27], [32]. Organic matter in soil stabilizes aggregates, helps prevent erosion, increases water-holding capacity, and is a source of slow-release nutrients [33]. Soil organic matter (SOM) depletion is linked to the decline of soil quality and is highly susceptible to management strategies [33]; [34].

6. Future Look

At present, a comprehensive assessment of soil health has never been done in Indonesia. Assessment and evaluation of soil conditions is commonly only carried out for agricultural activities, and even then only to recognize the type of soil and class of land suitability, it is not really assess the overall condition of the soil. In general, research on soil or land is only carried out on suitability for certain plants, land or soil surveys for identify soil types and its characteristics, and studies of soil characteristics related to crop production and fertilizer recommendations.

Considering that in Indonesia today the intensity of land use is increasingly intensive and land or soil management is inadequate, the problem of land and soil pollution, soil pollution and land degradation is expected to increase. To ensure a good quality of life, more serious attention and harder efforts are needed in the future to maintain and sustain soil health. For this reason, efforts should be made to establish soil health measurement or assessment techniques to assess or measure soil health periodically. Of course soil health is first measured as a baseline then followed by periodic monitoring and evaluation of soil health.

7. Conclusion

The technique of assessing or measuring soil health is very urgent and is needed in Indonesia, for this purpose it is necessary to immediately compile and establish ways or techniques for assessing or measuring soil health. Soil health measurement techniques need to be made simple, practical and can be used extensively with inexpensive costs. Thus the technique of measuring soil health needs to be supported by selecting the right key soil indicators or parameters.

Determination of a standard soil health assessment or measurement technique that can be used extensively is the starting point for an assessment of soil health at baseline and then periodic monitoring and evaluation can be carried out to determine whether soil health in an area remains, worsens or improves.

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