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Soil Health in Relation to Soil Biological Indicators

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Soil health is a critical aspect of sustainable agriculture and environmental stewardship. It refers to the overall condition and quality of the soil, including its physical, chemical, and biological properties. While physical and chemical indicators are commonly used to assess soil health, soil biological indicators provide valuable insights into the biological activity and functioning of the soil ecosystem. Soil biological indicators encompass various organisms such as bacteria, fungi, nematodes, earthworms, and other soil-dwelling organisms. These organisms play crucial roles in nutrient cycling, organic matter decomposition, soil structure formation, and disease suppression. Monitoring and understanding the abundance, diversity, and activity of these organisms can provide valuable information about soil health and its capacity to support plant growth and ecosystem resilience. By assessing soil biological indicators, farmers, researchers, and land managers can gain insights into the overall soil health and make informed decisions regarding land management practices. Furthermore, these indicators can help in evaluating the impacts of agricultural practices, such as tillage, fertilization, and pesticide use, on soil biodiversity and ecosystem functioning.

Characteristics of a Healthy Soil

1. **Good soil tilth:** Soil tilth refers to the overall physical character of the soil in the context of its suitability for crop production.

2. Sufficient depth: Sufficient depth refers to the extent of the soil profile to which roots are able to grow and function. Shallow depth :- as a result of a compaction layer or past erosion is more.

3. Sufficient but not excess supply of nutrients

a) An adequate and accessible supply of nutrients **:-**

1) Optimal plant growth
2) Maintaining balanced cycling of nutrients

b) Excess nutrients can lead to **:-**

1) Leaching
2) Ground water pollution
3) Toxicity to plants and microbial communities

4. Small population of plant pathogens and insect pests: In agricultural production systems, plant pathogens and pests can cause diseases and damage to the crop.

In a healthy soil:- population of these organisms is low and/or inactive.

In a unhealthy soil:- population of these organisms is high and/or active.

This could result from direct competition from other soil organisms for Nutrients or niche, Habitats and Hyper parasitism

5. Good soil drainage: Even after a heavy rain a healthy soil will:-

1) drain more rapidly – as result of good soil structure

2) an adequate distribution of different size pore spaces
3) retain adequate water for plant uptake.

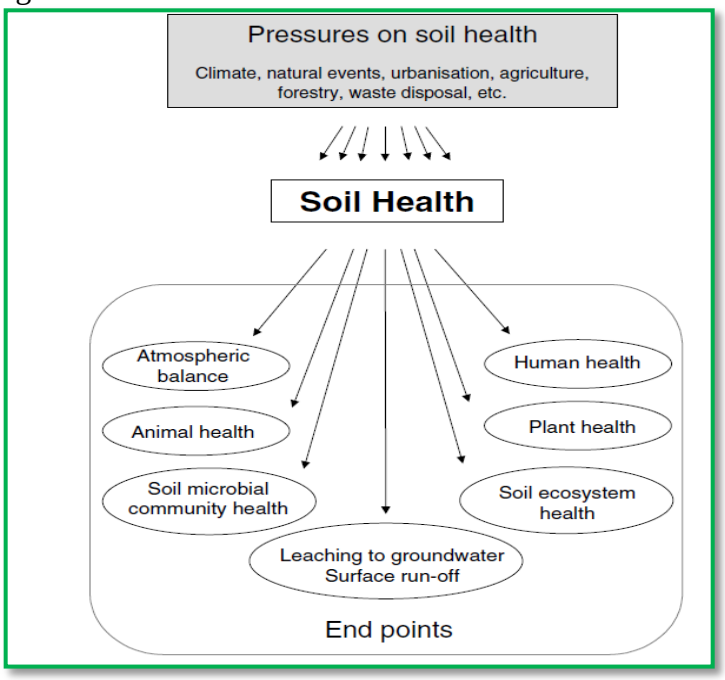
6. Large population of beneficial organisms: A healthy soil will have a high and diverse population of beneficial organisms to carry out these functions and thus help maintain a healthy soil status. Soil microbes play a significant role in functioning of the soil, help nutrient cycling, decomposition of organic matter, maintenance of soil structure and biological suppression of plant pests.

7. Free of chemicals and toxins that may harm the crop: Healthy soils are either devoid of harmful chemicals and toxins or can detoxify and/or bind such chemicals making them unavailable for plant uptake due to their richness in stable organic matter and diverse microbial communities.

8. Resistant to degradation: A healthy, well aggregated soil is more resistant to adverse events including erosion by wind and rain, extreme drought, vehicle compaction, etc.

Assessment of soil health

- Establishing assessment of condition and health of our soil resources is a vital to maintaining the sustainability of agriculture and civilization.
- In today energy and technology intensive world the need for maintaining the soil health of our soil resources is important.
- Target management practices to address soil constraints.
- Quantify soil improvement from implementing new or modifying current soil management practices.
- Facilitate applied research - compare management practices to develop a farm/field specific soil management program.
- Land evaluation – indication for soil health.



Framework for Evaluating Soil Health

A framework for soil health evaluation is critical for the development of a useful monitoring programme covering the different functions and land-uses and it must identify priorities and relevant indicators relating to policy-relevant end points.

Evaluation of soil health should be considered relative to the many different land uses, e.g.

- ✓ Agriculture
- ✓ Forestry
- ✓ Urbanization
- ✓ Recreation and
- ✓ Preservation

However we need a framework for evaluating soil health to identify problems in production area to make realistic estimates of sustainable food production, to monitor changes in environmental quality as related to agriculture management and to assist

government agencies in formulating and evaluating sustainable agriculture and other land use policies.

How to evaluate Soil Health?

Human health: visual symptoms, some internal tests (Urine, Blood etc)
Applying human health analogs to soil health is fairly straight forward.

Indicators

Indicators (definition): Soil quality indicators are processes and characteristics that can be measured to monitor changes in the soil, that give clues about how well soil can function.
Types of indicators: Indicators of soil quality can be categorized into three general groups: physical, chemical, and biological.

Biological indicators

- Soil organic carbon
- Soil microbial biomass
- Nitrogen mineralization potential
- Soil flora
- Soil fauna
- Soil respiration rate
- Earthworm

✓ **Role of biological indicators**

- Soil biological indicators are biological properties, processes, and characteristics that can be measurement of soil quality and health.
- Biological soil health can be measured from the biological indicators.
- The dynamic nature of soil micro-organisms and their sensitivity to various agriculture management practices make them an early indicator of soil quality.
- Agricultural practices affect many biological properties. The changes in these properties can be used to evaluate the impact of agricultural practices on soil quality.

Biological indicators in relation to soil health (Unit values of biological indicators reflects the soil health)

Sr. No	Biological indicator	Unit	Relationships to soil function and production
1	Potential mineralization N	Kg N/ha/30cm	Microbial potential activity, pools management effects of organic matter, relative C and N or CO_2 produced
2	Biomass C	Kg C/ha/30cm	Microbial potential activity, pools of C, Management affects of organic matter, relative C or CO_2 produced
3	Biomass N	Kg N/ha/30cm	Microbial potential activity, pools of N, Management affects of organic matter, relative N produced
4	Biomass P	Kg P/ha/30cm	Microbial potential activity, pools of P, Management affects of organic matter, relative P produced
5	Soil respiration	Kg C/ha/day	Relative microbial biomass activity, C loss, C input and total C pool
6	earthworms	No/m^3	Relative microbial biomass activity
7	Crop yield	Kg/ha	Plant available nutrient content, quality indicators, potential crop productivity, environmental health

- **Organic Matter and Soil Health:** Organic matter is any material that is derived from living organisms, including plants and soil fauna. Soil organic matter in its various forms greatly impacts on physical, chemical and biological properties of the soil. *Viz.*,

1) Soil aggregation,
2) Water-holding capacity,
3) Provides nutrients to the plant and
4) Energy to the soil microbial communities.

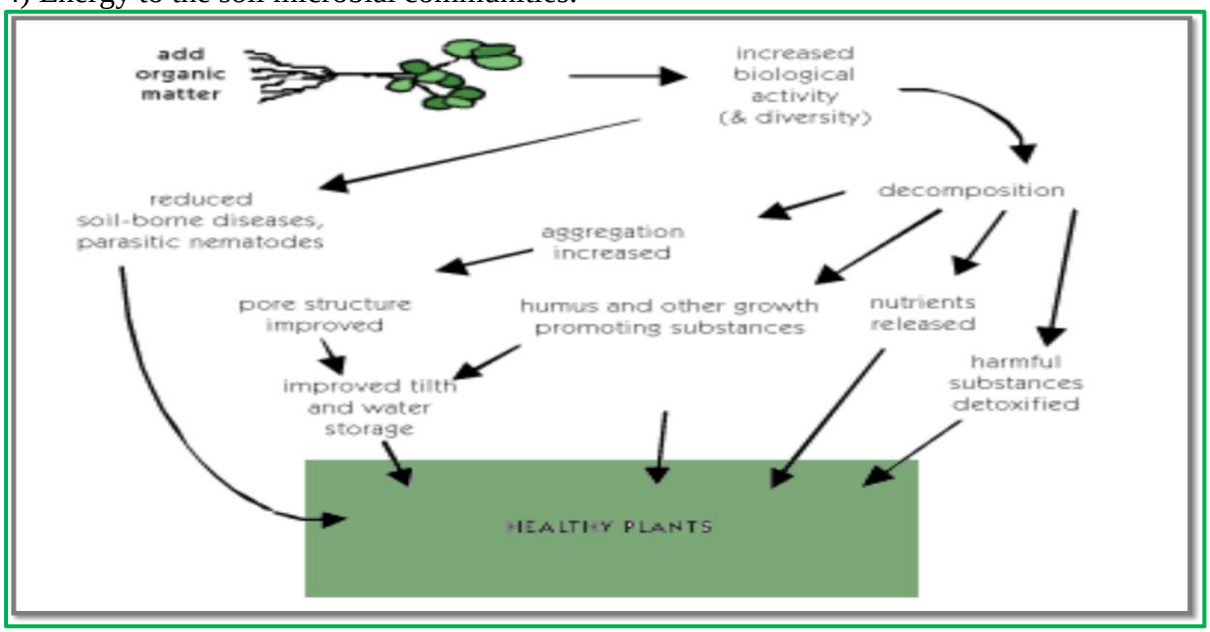
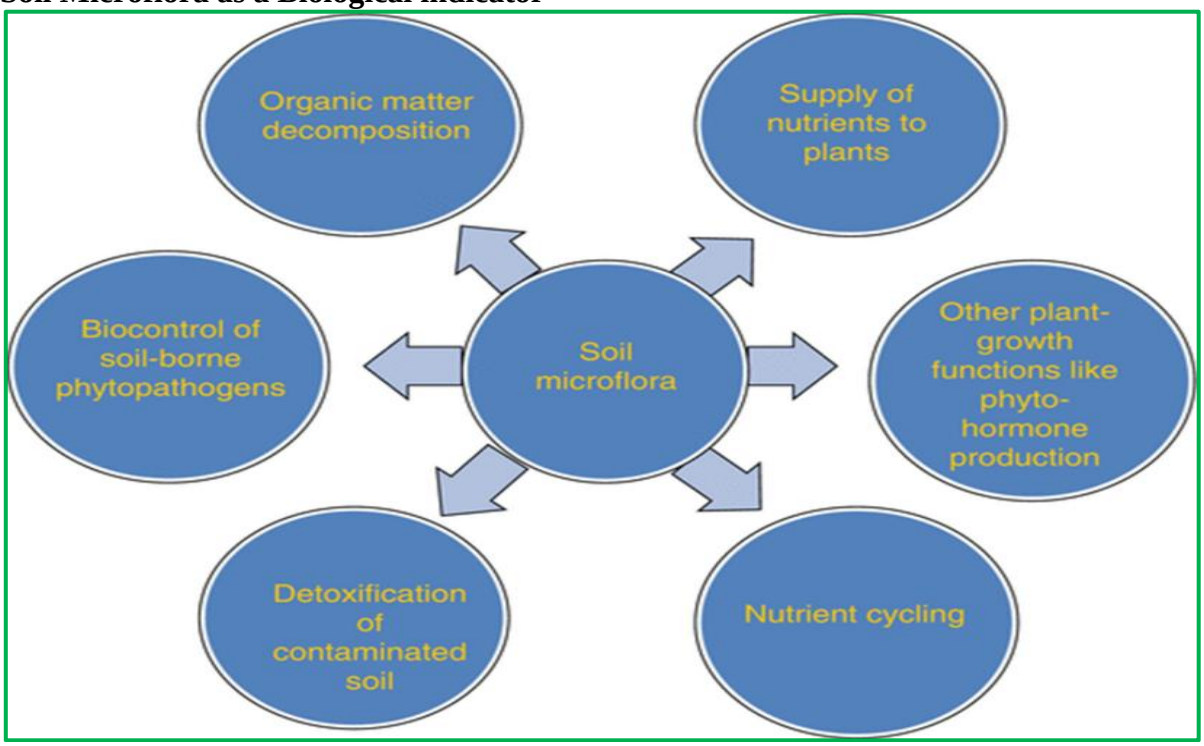


Fig. Adding organic matter results changes within the soil. (Source: Building Soils for Better Crops, 2nd edition, Sustainable Agriculture Network - USDA).

- **Relation of active carbon and soil health:** Active carbon is an indicator of the fraction of soil organic matter that is readily available as a carbon and energy source for the soil microbial community (i.e., food for the soil food web) "leading indicator" of soil health. Active carbon is positively correlated with percent organic matter, aggregate stability and With measures of biological activity such as soil respiration rate.
- **PMN and soil health:** Potentially mineralizable nitrogen (PMN) is an indicator of the capacity of the soil microbial community to convert (mineralize) nitrogen tied up in complex organic residues into the plant available form of ammonium and then nitrate.
- **Root health relates to soil health?** Root health assessment is a measure of the quality and function of the roots as indicated by size, color, texture and the absence of symptoms and damage by root pathogens

Poor root growth as a result of poor soil structure.

Soil Microflora as a Biological indicator



- **Number of earthworms relates to soil health:** Number of earthworms is indicator of soil health which affects the physical property of the soil mostly.
- **Soil microbial biomass C and N relates to soil health:** Microbial biomass represents a significant portion of the liable organic C pool in soils (Doran and Jonse, 1996). which can function as a reservoir of easily available nutrients or be catalyzed during the decomposition of organic matter (Brooks,1995). Soil microbial biomass acts both as source and sink of available nutrients and plays a critical role in nutrient transformation (Singh *et al*, 1989).
- **Soil respiration rate relates to soil health:** Soil respiration rate [as assessed by carbon dioxide (CO_2) evolution] is an indicator of soil biological activity. Soil CO_2 evolution results from the decomposition of organic matter; thus, soil respiration rate is an indicator of the amount of decomposition of that is occurring at a given time**.**

Soil enzymes as indicators of soil health

Soil Enzymes	Enzyme Reaction	Indicator of
Dehydrogenase	Electron transport system	Microbial activity
Beta-glucosidase	Cellobiose hydrolysis	C-cycling
Cellulase	Cellulose hydrolysis	C- cycling
Phenol oxidase	Lignin hydrolysis	C- cycling
Urease	Urea hydrolysis	N- cycling
Phosphatase	Release of PO_4	P- cycling
Arylsulphatase	Release of SO_4	S- cycling
Protease	Protein Breakdown	N- cycling

Conclusions

- Changing soil health Conditions need to give a new look to the Biological Indicator of Soil.
- The enzyme activities in soil after harvest of groundnut crop were improved with the inoculation of zinc solubilizers and thereby improved soil health.
- Soil health can be improved by adopting the suitable crops and cropping pattern that sequester more carbon.
- Improve nutrient management practices for better soil health through integrated nutrient management.
- Assessment of soil health biological indicators have prime importance and protect the soil from degradation.