



Soil Health and Human Health: The Hidden Link Through Food Nutrition

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Soil health plays a fundamental role in determining the nutritional quality of food and ultimately, human health. Healthy soils provide essential macro, secondary and micronutrients required for plant growth, which are transferred to humans through the food chain. However, modern agricultural practices such as excessive use of chemical fertilizers, monocropping and poor soil management have led to soil degradation and nutrient imbalances. This has resulted in reduced micronutrient content in crops, contributing to a global issue known as hidden hunger. Iron (Fe) and zinc (Zn) deficiencies are particularly widespread and have serious health consequences, including anemia and weakened immunity. Recent scientific studies have confirmed a strong link between soil nutrient status and human health outcomes. Therefore, improving soil health through sustainable practices is essential for enhancing food quality and ensuring better human nutrition.

Keywords: Soil health, Human health, Hidden hunger, Micronutrients, Food nutrition

Introduction

Soil is the foundation of agriculture and human life. It is not just a medium for plant growth but a living system that supplies essential nutrients to crops. These nutrients move from soil to plants and finally to humans through food. Therefore, the quality of soil directly determines the quality of food and human health. In recent years, agriculture has focused mainly on increasing crop yield to feed the growing population. However, this has led to excessive use of chemical fertilizers, continuous cropping and poor soil management practices. As a result, soil fertility has declined and the nutritional quality of food has decreased. This has created a serious problem known as hidden hunger, where people consume enough food but do not get sufficient essential nutrients like iron (Fe) and zinc (Zn). This condition affects millions of people, especially in developing countries like India.

Concept of Soil Health

Soil health refers to the ability of soil to function as a living ecosystem that sustains plants, animals and humans. A healthy soil maintains:

- ✓ Adequate nutrient availability
- ✓ Good structure and aeration
- ✓ High organic matter content
- ✓ Active microbial population

Healthy soils are biologically active and capable of nutrient cycling, ensuring that plants receive essential nutrients in available forms. However, modern agricultural practices such as excessive tillage, monocropping and overuse of chemical fertilizers have disturbed soil health, leading to nutrient imbalances and reduced fertility.

Soil-Plant-Human Relationship

The link between soil, plants and humans is a continuous cycle:

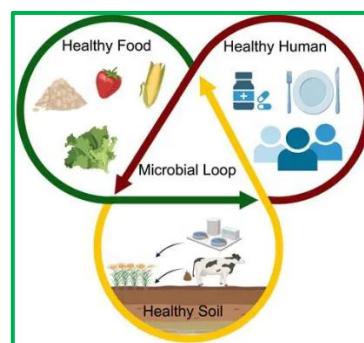
Soil → Plant → Food → Human Health

Soil: Provides essential macro (N, P, K), secondary (Ca, Mg, S), and micronutrients (Zn, Fe, Mn, Cu, B, Mo) for plant growth.

Plant: Absorbs nutrients, converts them into proteins, carbohydrates, vitamins and minerals.

Human: Consumes plants and gains essential nutrients needed for physical and mental development.

Any deficiency in soil nutrients directly affects plant composition and ultimately human nutrition.



Essential Nutrients from Soil

Macronutrients (N, P, K): Large quantities for growth, root development, photosynthesis and fruiting.

Secondary nutrients (Ca, Mg, S): Moderate quantities for structural support, enzyme activity and protein synthesis.

Micronutrients (Zn, Fe, Mn, Cu, B, Mo): Tiny amounts but crucial for enzymes, hormones and metabolic processes.

- ✓ Among these, iron and zinc are most critical for human health, as their deficiency leads to serious health disorders.
- ✓ Excessive reliance on NPK fertilizers without replenishing micronutrients creates nutrient imbalances, reducing both crop quality and human nutrition.

Hidden Hunger: The Invisible Crisis

Global Scenario

- ✓ Hidden hunger is a major global problem affecting both developing and developed countries.
- ✓ More than 2 billion people worldwide suffer from micronutrient deficiencies
- ✓ Around 733 million people are undernourished
- ✓ Zinc deficiency affects nearly 17% of the global population
- ✓ Iron deficiency is the leading cause of anemia worldwide

Indian Scenario

In India, soil nutrient imbalance is a major concern:

- ✓ Nearly 50% of soils are deficient in zinc
- ✓ Low organic carbon is common
- ✓ Imbalanced fertilizer use (high NPK, low micronutrients)

Hidden hunger is a serious problem where people consume enough food but lack essential micronutrients such as iron (Fe) and zinc (Zn). This problem is not only due to poor diet but is strongly linked with soil health.

The main reason behind hidden hunger is soil degradation. Continuous intensive farming, excessive use of chemical fertilizers, soil erosion and decline in organic matter have reduced soil fertility. As a result, soils are unable to supply sufficient nutrients to crops. Crops grown in such soils contain lower amounts of essential micronutrients, which directly affects human nutrition. In India, a large percentage of soils are deficient in nitrogen, organic carbon and micronutrient deficiencies like zinc and iron are also common. Globally, a significant portion of agricultural land is degraded, which reduces both crop productivity and nutritional quality. In addition to soil degradation, climate change is further worsening the problem. Rising atmospheric carbon dioxide (CO₂) levels reduce the concentration of iron and zinc in crops. High temperatures and irregular rainfall affect nutrient uptake and crop growth. Extreme weather conditions such as droughts and floods also damage soil and reduce crop quality.

Therefore, even if food production increases, its nutritional value decreases. This leads to a situation where people eat more but get fewer nutrients, resulting in hidden hunger.

Health Impacts

Hidden hunger has serious long-term effects on human health:

Iron deficiency → Anemia, weakness, fatigue

Zinc deficiency → Weak immunity, stunted growth in children

Factor	Effect on soil/crops	Impact on humans
Soil degradation	Loss of nutrient in soil	Nutrient poor crops
Excess fertilizers	Nutrient imbalance	Low micronutrient food
Soil erosion	Loss of fertile soil	Reduced crop quality
Climate change	Reduced Fe & Zn in crops	Anemia, weak immunity
High temperature	Poor nutrient uptake	Malnutrition
Extreme weather	Crop damage	Food insecurity

Scientific Evidence Linking Soil and Human Health

In recent years, scientific research has clearly proven that soil health directly affects human health through food nutrition. Earlier, this link was theoretical, but now strong data-based studies confirm it.

One of the most important studies, published in Scientific Reports in 2023, analyzed 27 million soil samples along with health data from 300,000 children and 1 million women in India.

Key Scientific Findings

1. Soil Zinc (Zn) and Child Growth

- ✓ Areas with better soil zinc levels had less child stunting
- ✓ Increase in soil zinc reduced stunting cases significantly
- ✓ Shows that soil nutrients affect physical development
- ✓ Low zinc in soil → Low zinc in crops → Poor child growth

2. Soil Iron (Fe) and Anemia

- ✓ Soil iron levels were directly linked to hemoglobin levels in women and children.
- ✓ Low soil iron → Low iron in food → Higher anemia cases

3. Soil Fertility and Public Health

- ✓ Regions with good soil nutrient status showed: Better child height and lower malnutrition rates
- ✓ Soil micronutrients act as a hidden driver of nutrition

Government Initiatives

Soil Health Card Scheme - Promotes soil testing

National Food Security Mission (NFSM) - Supports balanced fertilization

Biofortification Programs (ICAR) - Develop nutrient-rich crops

Improving Soil and Human Health

To ensure better soil fertility and human nutrition, the following practices are important:

1. **Balanced Fertilization:** Use fertilizers based on soil testing and include micronutrients along with NPK.
2. **Organic Matter Addition:** Application of farmyard manure (FYM), compost and green manure improves soil structure and nutrient availability.
3. **Biofertilizers:** Use of beneficial microbes helps in nutrient fixation and improves soil health.
4. **Crop Rotation and Diversification:** Growing different crops helps maintain soil fertility and reduces nutrient depletion.

5. Soil Testing: Regular soil testing helps farmers understand nutrient status and apply correct fertilizers.

6. Biofortification: Growing nutrient-rich crop varieties (*e.g.*, zinc-rich wheat, iron-rich rice) helps improve human nutrition.

Conclusion

Soil health is directly linked to human health through food nutrition. Degraded soils produce nutrient-poor crops, leading to hidden hunger and serious health problems. Improving soil fertility through sustainable practices is essential not only for increasing crop productivity but also for ensuring better human health. Therefore, the concept of “Healthy Soil, Healthy Food, Healthy People” must be adopted for sustainable development.