Soil Pollution and Human Health

Soil and Human Health Challenges

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Introduction

Soil plays a crucial role in human health, offering both risks and benefits. While past focus has been on the negative impacts such as toxins, pathogens, and nutrient-poor crops healthy soils also support human well-being through food production, nutrient supply, medicinal resources, and immune system enhancement. Soil is a complex ecosystem, and its health directly affects human health. However, there are major gaps in our understanding of how chemical mixtures and biological interactions in soil influence people. More research is needed, especially on macroorganisms, and better integration of soil science with health and nutrition fields is essential. Effective communication and .

collaboration among multidisciplinary teams are key to advancing this field and raising public awareness.

In 1948, the World Health Organization (WHO) described health as a state of full physical, mental, and social well-being, rather than merely the absence of illness. According to the US Department of Health and Human Services, achieving this ideal of health is influenced by various factors, including access to economic opportunities, the availability of resources in homes and communities, the quality of education, workplace safety, and the cleanliness of food, water, and air, as well as the quality of social relationships.

Soil Pollution and Human Health

Soil influences human health in both direct and indirect ways by supplying essential nutrients like selenium and zinc through plants, while also posing health risks due to natural toxins or contamination from human activities, especially in urban areas. It is a natural source of antibiotics, but the widespread use of antibiotics in agriculture and medicine has led to the spread of antibiotic resistance genes, raising public health concerns. Recent research, including four review articles, explores various aspects of this soil

health connection: Steffan *et al.*, (2018) highlight the broad effects of soil on health and the need for interdisciplinary research; Cakmak & Kutman (2018) address zinc-deficient soils and biofortification; Li *et al.,* (2018) examine urban soil health and pollution; and Xie *et al.,* (2018) focus on the transfer of antibiotic resistance from animal manure to soil. These studies underscore the importance of further investigation into the complex relationship between soil and human health and showed in the fig. 01.

Fig. 01. How to Soil pollution affect the Soil and Human Health
SOURCE: Food and Agriculture Organization of the United Nation

Factor affecting the Soil Pollution and Human Health

1.Chemical Factors
   i.   Toxins and pollutants (e.g., heavy metals, pesticides, industrial waste).
   ii. Chemical mixtures in soil that can interact in unknown or harmful ways.
   iii. Nutrient availability in soil (e.g., lack of essential minerals affects crop and human nutrition).

2. Biological Factors
   i.   Pathogenic organisms (harmful bacteria, viruses, fungi in soil).
   ii. Soil microbiota (beneficial microbes that support plant growth and immunity).
   iii. Macroorganisms (e.g., earthworms, insects), which impact soil structure and health.
   iv. Biodiversity in soil ecosystems, influencing ecosystem stability and productivity.

3. Physical Factors
   i.   Soil structure and texture.
   ii. Water retention and drainage.
   iii. Erosion and compaction, which affect soil productivity and quality.

4. Agricultural Practices
   i.   Use of fertilizers and pesticides.
   ii. Monoculture **vs.** crop rotation.
   iii. Tillage practices.
   iv. Organic farming vs. conventional methods.

5. Environmental Factors
   i.   Climate change (affects soil moisture, temperature, and microbial activity).
   ii. Deforestation and land use changes.
   iii. Pollution from air, water, or urban development.

6. Human Activities and Policy
   i.   Industrial and urban development.
   ii. Waste disposal.
   iii. Regulations (or lack thereof) on soil contamination.
   iv. Public awareness and education.

Impact of Soil Pollution on Soil and Human Health

1. Impact on Soil Health

Soil pollution severely degrades the **biological, chemical, and physical properties** of soil, leading to:

i. **Loss of fertility**: Accumulation of heavy metals, pesticides, and industrial chemicals interferes with nutrient cycling and plant growth.

ii. **Disruption of soil microbiota**: Pollutants harm beneficial microbes essential for nutrient processing and disease suppression.

iii. **Reduced biodiversity**: Toxic substances diminish populations of soil organisms (e.g., earthworms, fungi, bacteria), weakening the soil ecosystem.

iv. **Altered pH and structure**: Some contaminants change soil chemistry, affecting water retention, root penetration, and aeration.

v. **Soil degradation**: Pollution can contribute to erosion, compaction, and reduced organic matter, ultimately making soil unfit for agriculture.

2. Impact on Human Health

Humans are exposed to soil pollutants via **direct contact**, **inhalation of dust**, or **consumption of contaminated food and water**, leading to:

i. **Toxicity and poisoning**: Heavy metals like lead, cadmium, arsenic, and mercury can accumulate in the body, causing neurological damage, kidney failure, and developmental issues.

ii. **Cancer risks**: Exposure to carcinogenic compounds such as polycyclic aromatic hydrocarbons (PAHs), benzene, and dioxins in soil increases cancer risk.

iii. **Endocrine disruption**: Certain pesticides and industrial chemicals in soil act as endocrine disruptors, affecting hormones and reproduction.

iv. **Respiratory issues**: Inhalation of contaminated soil dust (especially in dry, urban areas) can cause asthma, bronchitis, and other lung diseases.

v. **Food safety concerns**: Crops grown in polluted soil can absorb harmful substances, leading to **bioaccumulation** and **food chain contamination**.

Examples of Pollutants and Their Effects:

Pollutants	Soil Health Impact	Human Health Impact
Lead (Pb)	Inhibits microbial activity, reduces fertility	Neurotoxicity, developmental delays in children
Cadmium (Cd)	Alters soil enzyme activity	Kidney damage, bone weakness
Arsenic (As)	Reduces crop productivity	Skin lesions, cancer, cardiovascular diseases
Pesticides	Harms beneficial insects and microbes	Endocrine disruption, cancer, neurological effects
Petroleum hydrocarbons	Contaminates organic matter, affects soil texture	Liver toxicity, cancer, immune system issues

Mitigating Soil Pollution and Health Impacts:

Mitigating the impact of soil pollution on human health involves a combination of **prevention, remediation**, and **sustainable practices**. Here are some key strategies to reduce soil contamination and its effects on human health:

1. Soil Pollution Prevention:

a. Sustainable Agricultural Practices

i. **Reduce pesticide and fertilizer use**: Promote integrated pest management (IPM) and organic farming to limit chemical runoff and soil contamination.

ii. **Use biofertilizers**: Substitute chemical fertilizers with organic or bio-based alternatives that enhance soil health without contributing to pollution.

iii. **Crop rotation and polyculture**: Reduces soil depletion, pest buildup, and prevents the overuse of chemicals on monocultures.

iv. **Cover cropping and reduced tillage**: Helps improve soil structure, organic matter content, and reduces erosion, limiting soil degradation.

b. Improved Waste Management

i. **Proper disposal of industrial waste**: Ensure industries treat and dispose of hazardous waste properly to prevent contamination of surrounding soils.

ii. **Sewage and wastewater treatment**: Properly treat wastewater and sewage to prevent pathogens and harmful chemicals from leaching into the soil.

2. Soil Remediation Techniques

a. Phytoremediation

i. **Use of plants to clean contaminated soil**: Certain plants, like sunflowers and mustard, can absorb heavy metals and other pollutants from the soil. This process helps to reduce contamination in the soil and prevent further uptake by crops.

b. Bioremediation

i. **Microbial treatment**: Beneficial soil microbes can be used to break down organic pollutants like petroleum hydrocarbons or pesticides, effectively cleaning the soil.

c. Soil Washing

i. **Leaching of contaminants**: This process involves washing the soil with a solution to dissolve pollutants (like heavy metals) so they can be removed.

d. Soil Stabilization

i. **Binding contaminants**: Involves adding materials like lime or biochar to contaminated soil to "lock" pollutants in place, reducing their mobility and toxicity.

3. Enhancing Soil Health and Sustainability
a. Soil Erosion Control

i. **Terracing and contour farming**: Techniques like terracing and contour plowing help reduce soil erosion and prevent the spread of pollutants.

ii. **Reforestation**: Planting trees and vegetation can help restore degraded soils, preventing further erosion and improving biodiversity.

b. Organic Farming and Composting

i. **Organic farming**: Encourages the use of compost and organic manure, reducing dependence on chemical fertilizers and promoting healthier soils.

ii. **Composting**: Enriches soil with organic matter, improving structure and promoting beneficial microbes.

c. Soil Conservation Practices

i. **Cover crops**: Planting cover crops such as legumes during the off-season prevents soil erosion, enhances soil fertility, and reduces soil degradation.

ii. **Agro-forestry**: Integrating trees into agricultural landscapes can improve soil health by reducing erosion, increasing organic matter, and improving water retention.

4. Research and Technology Integration
a. Advancing Soil Testing and Data Analytics

i. **Regular soil testing**: Implement comprehensive soil testing to detect pollutants (heavy metals, pesticides, etc.) and track the effectiveness of mitigation strategies.

ii. **Advanced data analytics and GIS**: Use Geographic Information Systems (GIS) and data analytics to map and monitor soil quality in real-time, providing actionable insights.

b. Biotechnology and Genetic Engineering

i. **Genetically modified crops**: Develop crops that are more resistant to soil contaminants or capable of absorbing and detoxifying pollutants from the soil.

ii. **Microbial solutions**: Use bioengineered microorganisms to degrade toxic chemicals in the soil.

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