SOIL DEGRADATION: A PIVOTAL ENVIRONMENTAL CONCERN

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ABSTRACT

Saving the environment for today and for tomorrow is the biggest ethical responsibility of the current human race. We have caused extreme damage to the air we breathe, the water we drink and the food we eat. We have been selfishly exploiting our resources and degrading them for future use. Overpopulation, pollution, deforestation, desertification, excessive industrialization, and above all, unsustainable agricultural practices are causing global warming & extreme climate changes and posing a big threat to food security and safety. Ninety five percent of the food we eat comes from the soil (FAO). A report by the UN in 2019 stated, "The current food system is fueling the destruction of Earth's forests — and humanity must overhaul how we grow and ship food to stop climate breakdown." By 2050, the population of Earth will be nearly 10 billion, but the countries of the world are unable to sustain the pressure of producing enough food and maintaining sustainable agriculture at the same time. A quarter of the world's soils are degraded; a degraded patch of land is not only infertile, but it also releases carbon dioxide and nitrous oxide into the atmosphere, adding to GHGs. Studies all over the world warn that due to unsustainable agricultural practices the world is losing 24 billion tons of fertile soil every year. At this pace, by 2050, 95% of earth's soils will be degraded. Hence, contemporary times are the most critical to conserve soil— for our present and our future!

Keyword: - *Soil, Degradation, Conservation, Regenerative, Agriculture etc.*

1. INTRODUCTION

"In nature's economy the currency is not money, it is life." Vandana Shiva.

The elements of nature – air, water, minerals, organic matter react miraculously with each other to make soil – earth's priceless, limited, and very dynamic natural resource! Soil has many uses and hence has different definitions for the users – it is a medium for plant growth for a agriculturist; the base for construction for an engineer; a territorial boundary for a soldier. Scientifically, soil can be defined as, "The surface mineral and/or organic layer of the earth that has experienced some degree of physical, biological, and chemical weathering."

Soil, the fragile skin of earth is the basis of the entire living system thriving on it and in it. It anchors the plants and nestles the communities of micro-organisms, microscopic animals, earthworms, termites, etc. Soil is the intersection between the living and the dead; it is the life's recycler. The micro life in the soil recycles organic matter and dead organisms into the foundation of new life. The soil's incredible ecosystem is a water purifier, filter and store house; it converts contaminated material into simple compounds, makes pathogens harmless, and stores water during its passage. It is the provider of food, pure water, shelter, and new life!

The structure, depth, texture and fertility of the soil differs greatly by location. These differences allow soil to be useful in multiple ways in the global ecosystem:

- Soil is the medium for plant growth. It provides anchorage to the roots and stores & supplies nutrients for plant growth. This ability of soil is called fertility. Soil fertility is more critical now than ever before, as the crop demand is predicted to increase by 100-110% by the year 2050.
- Soil absorbs the extra moisture from rain and snow, serving as a storehouse of water for the plants during the dry spells in between the rain and irrigation periods. Absorption of extra water also mitigates the dangers of floods. Many layers of micro-biota, organic matter and minerals filter the water of harmful contaminants

through various biological, physical and chemical processes. So, a healthy soil is a store house and purifier of water and protects from droughts and floods.

- Soil is the recycler of life! The micro flora and fauna of the soil ecosystem decompose the organic matter and dead organisms and transform the remains into simple mineral forms that make soil humus and are used by other micro-biota, plants, and animals in formation of new living tissue.
- Soil is the second largest storehouse of biologically active natural carbon after the oceans. Through process of decomposition and recycling by the microscopic communities, soil stores unprecedented amount of atmospheric carbon and nutrients, which can stay in the soil for centuries. This storage of carbon in the soil is called carbon sequestration. Soil stores about 2500 GT of carbon, which is 80% of the total carbon on earth (3170 GT approx.).
- Soil is a major contributor to the finances of the world economies. It is the medium for crop growth and base material for roads, homes, buildings, highways and other structures set upon it. Soil degradation has had a major financial impact worldwide due to lower crop production and increased water consumption.

However, soils across the globe are abused, exploited and damaged by anthropogenic activities. Mechanization and extensive use of chemicals in agriculture is leading to widespread degradation of soil.

2. SOIL DEGRADATION AND ITS IMPACTS

"The nation that destroys its soil destroys itself." Franklin D. Roosevelt

Decline in soil's physical, biological, and chemical state is Soil Degradation; it is mainly caused by improper use of soil or its poor management. Excessive, improper & abusive agriculture, industrial & mining activities, fossil fuel extraction & processing activities, improper & irresponsible waste disposal, transport emissions, etc. are the main contributors to the fast paced and wide spread soil degradation. Soil degradation causes deteriorative changes in the alkalinity, acidity or salinity of the soil, which deteriorates soil's natural structure and leads to decline in soil fertility.

Main causes of soil's physical, chemical, and biological degradation are:

- Natural physical factors like water and wind erosion are the major causes of soil degradation:
  - Excessive rainfall and floods leading to surface runoff, wind erosion, and mass movement of soil, etc. produce various soil detachment actions and wear away the soil's top layer as well as organic matter. Eventually, the natural composition and structure of the soil changes, which leads to a decline in soil fertility.
- Anthropogenic physical factors like mechanization of agriculture and improper farming practices are the main contributors to physical deterioration of soil; estimated rates of accelerated soil erosion on arable or intensively grazed lands are 100-1 000 times higher than natural erosion rates (FAO). Adding to the ill effects of unsustainable agriculture are urbanization & industrialization, mining, and fossil fuel extraction & processing activities:
  - Deep plowing, intensive tillage using heavy machinery fractures the soil and disturbs the natural soil structure, expediting surface runoff and soil erosion. It also reduces the crop residue, which exposes the soil particles to heavy rain and wind. Extensive use of heavy machinery eventually compresses the soil leading to soil compaction: aeration and water holding capacity of soil is reduced. This in turn distresses root penetration, sprout emergence, and water & nutrient absorption by plants.
  - Agricultural practices like over-farming, mono-cropping, row-cropping, surface irrigation, slash burning, and land clearance, etc. also have a harmful effect on soil fertility as these activities alter the natural composition of the soil and prevent the soil from regenerating.
  - Overgrazing of the grasslands takes away the crop cover from the soil surface making it more vulnerable to water and wind erosion.
  - Removal of trees and crop cover exposes the soil minerals to erosion and buildup of toxicities. Vegetation cover binds the soil particles together and the humus and litter layer at forest ground promotes soil formation. Plant cover is very important for soil's water holding capacity, aeration, and biological activities.
  - Extensive construction activities for urbanizing cover the land with materials like concrete. When an impenetrable material like concrete covers soil for a long time, it looses its natural fertility and agricultural potential.
  - Mining activities leave the land bare and expose them to the threat of erosion and desertification.
  - Fossil fuel extraction and processing activities of finding, processing, and moving fuel deposits has deleterious effects on the land and ecosystems. In many cases huge patches of land including entire

mountaintops, big areas of forests are blasted away to unearth the fuels; the affected piece of land is nutrient-leached and more prone to erosion. Its fertility plummets many folds.

- Chemical deterioration of soil is the alteration of the chemical properties of the soil. Stalinization, acidification, water logging, soil pollution, and loss of nutrients or organic matter are some of the major causes of chemical degradation of soil. Various anthropogenic activities are deteriorating soil's chemical properties:
  - Misuse or excessive use of chemical fertilizers, fungicides, herbicides, pesticides, etc. has harmful effects on the microbial life in the soil. These chemicals disturb the communication between the plants and the microbes by changing the bio chemical behavior of the micro organisms, which in turn negatively impacts the nutrient availability for the plants and the micro biota. However, only 0.1% of the chemical used to treat nutrient deficiency or kill a target organism is effective, 99.9% of it remains in the soil until degradation, which may take a very long time. Hence, continuous use of chemicals can permanently alter the chemical composition of the soil and can damage the soil humus and its microbial health.
  - Improper waste disposal activities, intensive industrial activities, mining activities, and fossil fuel extraction & processing activities, etc. diffuse a variety of chemicals toxins into the atmosphere, rivers, land, and groundwater; which eventually leach into the soil and degrade its chemical properties.
- Harmful plant growths and anthropogenic activities disturb the biological nutrient balance of the soil. Some bacterial and fungal overgrowths are harmful for the micro-flora and reduce the microbial activity of the soil leading to a reduction in crop yield and soil productivity. Abusive and irresponsible farming techniques exploit the nutrient content of the soil and deplete fertility.

3. SOIL CONSERVATION

"Eventually, all life depends upon the soil…there can be no life without soil, and no soil without life; they have evolved together" – USDA Yearbook of Agriculture, 1938.

Merriam-Webster dictionary defines soil conservation as:

"The prevention or reduction of soil erosion and soil depletion by protective measures against water and wind damage."

"Management of soil so as to obtain the largest crop yields feasible and improve the soil at the same time."

Soil is a living eco-system. It is the basis of healthy plant growth and animal life. Soil is home to millions of micro biota. These micro flora and fauna breakdown the organic matter, release nutrients, and open up spaces for aeration and water circulation & holding. Hence, the health and fertility of the soil is directly proportionate to the health of the microbiological life thriving in it. Dead plant and animal matter is the source of food and energy for these micro biota; so, to maintain healthy soil life, it is essential to replenish the soil with organic matter on a continuous basis and do not pollute the soil with harmful chemicals. There should be at least 5% organic matter content in the soil to be considered healthy. If the soil becomes unhealthy the entire life cycle will be unhealthy and will eventually come to a halt.

The top 5-10 inches of soil holds most of the vital nutrients for plant growth and is the host for all the significant microbial activities. Top soil loss is a major concern for the global farmer community whose livelihood depends on agriculture. Agriculture faces the daunting task of feeding the ever-growing population of earth. Unfortunately, the equivalent of one soccer pitch of soil is eroded every five seconds (FAO and ITPS, 2015); 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050 (FAO and ITPS, 2015; IPBES, 2018). Hence in agriculture, it is estimated that soil erosion can lead up to 50 percent loss in crop yields (FAO).

There are many factors that hinder soil conservation; but, abusive and unsustainable agricultural practices like slash and burn, land overuse, and chemical contamination are the main offenders.

Fortunately, many environmentally conscious agricultural techniques can be instrumental to save soil among which are:

- Agronomic ways - regenerative agriculture practices, contour farming, etc.
- Vegetative remedies - live fences, planting barriers (vegetative strips), windbreaks, etc
- Structural techniques - terraces, barriers, bunds, banks, cut off drains, etc.
- Land management practices - selective clearing, area closures, etc.

There are many other ways to conserve soil, like managing the salinity of soil and maintaining healthy microbial life in soil. Irregular and unsustainable irrigation using saltwater causes salty soil, and the pesticides and herbicides kill the soil organisms. Hence, the farmers of the world need to acknowledge the negative impacts of unsustainable agricultural techniques and make a move towards more sustainable practices.

4. CONCLUSION AND WAY FORWARD

"A true conservationist is a man who knows that the world is not given by his fathers, but borrowed from his children." John James Audubon

Currently, over a third of global soil resources are either moderately or highly degraded. In last 150 years, the planet has lost half of its topsoil. Unfortunately, most of this destruction has been caused and is being expedited by exploitative anthropogenic activities. While there are many challenges to maintaining healthy soil, there are many good reasons to conserve this humble dirt beneath our feet:

- Limited natural resource: Soil is considered to be a renewable because it is constantly forming, but soil formation occurs at extremely slow rates. It can take more than 1000 years to make 2-3 cm of soil.
- Soil is the basis of life: Healthy soil means healthy life; one handful of soil contains more living organisms than the entire population of earth. The world beneath our feet is so full of life! This diverse, complex and rich network of micro organism communities in the soil fortify the healthy food production system and underpin the vegetation for fuel and feed. If we want a healthy and prosperous life ON soil, we ought to conserve the life IN the soil. Healthy soil enhances crop quality and quantity over time. Hence, improves farmers profit through increased yields.
- Preserves bio-diversity: Improved soil quality enhances the quality of the environment for all types of plants and animals; leading to the preservation of wild flora and fauna and hence increasing bio-diversity.
- Key to the carbon cycle: Abused and poorly managed soil releases excess carbon dioxide to the atmosphere, contributing to climate change. Using soil conservation practices in agriculture can restore degraded soil and can effectively sequester carbon, which will build a soil resilient to the effects of climate change. Today, we are facing a climate emergency– sea surface temperatures are raising; forests are burning; rivers, lakes, and reservoirs are shrinking. The citizens and governments of the world are acknowledging the climate crisis and working towards a meaningful solution. A big part which is under our feet– only a 2% increase in soil carbon can absorb the entire excess carbon on earth!
- Eventual increase in profit for the farmer: Conservative farming practices increase the quality of soil, which eventually reduces the amount of fertilizers, pesticides, and labor usage; cuts down the cost associated with machinery and its maintenance & fuel. Over a period, as the fertility of the soil enhances the crop yield becomes comparable to or more than conventional farming.

The population of the world and hence the negative impacts of climate change on the vegetation are on a constant increase. Our soils are facing a growing demand to provide more food, clean water, and raw materials; it is the most critical and ethical responsibility of our generation to manage the soil and its associated resources like the bio-energy carefully, only then we can avoid risks to food security & safety, biodiversity, and land degradation. Positive outcomes are achievable through right governance systems and locally appropriate policies:

- The academia, policy makers and the farmer community needs to work together to plot the required measures for identification and restoration of the degraded soils. Hence, it is important to educate the local farmer about soil degradation and its consequences and develop area specific soil protection mechanism by synergizing biological and mechanical techniques.
- Greater cooperation and partnerships among the local & global farmer communities, national & international governments and the citizens of the world is a must to share the knowledge and successful practices.
- Cohesive set of rules should be developed globally and every nation should be made available with every green, clean and sustainable technology developed in the world.

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