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Address for correspondence:
Dr. S. P. Gudadhe
Department of Botany, Arvindbabu Deshmukh Mahavidyalaya, Bharsingi
Email: smitagudadhe@gmail.com

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Soil Restoration for Sustainable Agriculture-A review

Dr. S. P. Gudadhe
Department of Botany, Arvindbabu Deshmukh Mahavidyalaya, Bharsingi

Abstract

Soil the main factor of nature, which regulates the various cycles, responsible for the generation of plants and various lives on earth, and remove the contaminants. It provides the various nutrients to developing plants, habitats, and fundamental aspect for the food chain. There are numerous minerals and nutrients, which is the main requirement of plants, such as nitrogen, phosphorus, and potassium, are the role compound of the soil. The total effects of human activities and natural processes as deforestation, terrific grazing, and population through diverse sectors are some of the primary reasons for the degradation of soil. These inappropriate activities affects soil structure through erosion, depletion in nitrogen content, salinization, compaction of soil, which damage the better qualities of soil and does not support the plant life and also harm other ecological processes and degrade soil health and productivity. The main objective of soil restoration is to improve the soil structure, nutrition contents through natural and application of technological approaches. The main strategies are to increase soil organic matter, porosity or proper aeration of soil and improve water-holding capacity of soil, which benefited to the high productivity and high yield. The methods and procedures that are crucial for improving the fertility, restoration, and condition of the soil were the main emphasis of the current study. The necessary procedures required for the understanding of the restoration of soil to balance the whole ecosystem is the main aspect of this research paper.

Keywords: *Soil restoration, Soil degradation, Sustainable agriculture, Soil fertility, Soil erosion, Organic matter, Soil biodiversity, Soil management*

Introduction

The Loss Of Land's Physical, Chemical, Biological, And Ecological Characteristics Because Of Natural Or Man-Made Disturbances Is Referred To As Soil Degradation. Soil Erosion, Mining, Natural Disasters, Agricultural Practices, And The Use Of Land For Different Purposes And Management Are The Primary Drivers Of Soil Degradation. The World's Food Supply Is At Risk Due To The Alarming Rate At Which Soil Degradation Is Spreading, Affecting Land Fertility And Production. Land Degradation Reduces Soil Quality And Thus The Future Potential For The Survival Of Living Creatures (Fitzpatrick 2002). Soil Degradation Mainly Caused By Physical, Chemical, And Biological Degradation Of Soil.

Physical Factor: Compaction, Crusting, And Enhanced Erosion Are Examples Of Physical Soil Degradation, Which Is The Breakdown Of Soil Structure. Heavy Rainfall, Strong Winds, Flooding, Wildfires And Climate Change Are Various Factors Causes The Soil Erosion, Which Runs Off The Top Soil And Organic Content. The Physical Factors Runoff The Surface Soil Particles And Conduct The Soil Erosion (Mainly Water And Wind Erosion) And Also Replace The Composition 0f Organic Matter And Structure Of The Soil. In The Long-Term, The Physical Forces And Weathering Processes Lead To The Decline In Soil Fertility And Adverse Changes In The Soil's Composition/Structure (Https://Moirabaricollegeonline.Co.In/Attendence/Classnotes/Files/1589556322.Pdf).

Chemical Factor: Soil Pollution, Salinization, Acidification, And Nutrient And Organic Matter Loss And Decline In Fertility Of Soil Are Chemical Components Of Soil Deterioration. The Fertility Of Soil Is Depend Upon The Nutrient And Chemical Structure Of The Soil And Any Adverse Effect On The Nutrient Content Of The Soil Directly Affects Its Fertility And The Production System. Chemical Deterioration Of Soils Is Often Also Due To Agricultural Over Exploitation, Relying Solely On Replenishing Nutrient Losses Through Harvesting By Artificial Fertilisers. Artificial Fertilisers Responsible For An Imbalance In Soil Due To The Lack Of Ability To Balance All Nutrients. (Fao/Agl, 2000).

Biological Factors: Human activities such as inappropriate farming, deforestation, and livestock grazing destroy native plants and reduce soil structure. Additionally, excessive pesticide and fertilizer usage can alter soil's native microbial population, reducing soil fertility and agricultural output. Injudicious use of natural resources, mining for exploitation of earth reserves and industrialization is depleting soil organic matter which in turn may be eroding soil biodiversity and in long term affecting soil fertility and agriculture productivity (Mishra and Dhar, 2004).

Deforestation: Deforestation is the long-term removal of forest habitats for timber harvesting, farming, and urbanization. Multiple factors have been reported to be responsible for deforestation and habitat loss, which could either be of human or natural origin. Natural causes of deforestation could be as result of forest fires, droughts, exotic animals, floods, overpopulation of foreign animals and climate change (Bodo *et al*, 2021). Due to the deforestation the loss of nutrients content in the soil affects which leads to the disturbance in microflora of soil, affect the soil fertility, causes soil erosion ultimately the negative impact on the environment.

Exploitation or excessive utilization of fertilizers: Excessive and improper use of chemical fertilizers and pesticides can harm microorganisms that help to hold the soil intact. Overuse of chemical pesticides and fertilizers in agriculture can destroy important bacteria and microorganisms that aid soil development. Exploitation of chemical fertilizers degrade the soil quality as well as the effects the ground water characteristics, increase the air pollution and ultimately harm human health. Fertilizers with excessive amounts of salt may damage plants, while over fertilization can cause fast growth and weak root systems.

Industrialization, Commercialization and mining processes:

The main ways that industrialization, commercial farming, and mining operations degrade soil includes by means of the loss of vital nutrients and organic matter, physical disturbance and degradation the soil structure, and contamination by hazardous chemicals and heavy metals. The essential components of industrial development that is mining activities play a vital role in the economy of nation. However, they frequently have serious environmental impacts, especially soil pollution by heavy metals **(Dehkordi *et al.,* 2024).**

Urbanization: Urbanization, or the increased concentration of human populations in cities, is a global phenomenon that is changing landscapes and ecosystems. This abrupt transition from rural to urban living has a major influence on the natural environment, with one of the most important, but frequently underestimated, consequences being soil quality (https://climate.sustainability-directory.com/question/how-does-urbanization-affect-soil-quality/). The various developments in rural sector for the transformation in urban area resulting in soil degradation, compaction of soil, erosion and adverse environmental effects. The urban communities due to these conditions also faces the natural hazards and calamities.

Inappropriate agricultural practices: Agricultural activities play a vital role in overall health of soil, climate and human life. Day by day, the agriculture production is increased to meet the various trends of the societies. It caused pressure on the agriculture sector, negatively affecting the health of the soil. Degradation of the soil is usually a main problem of less developed areas of the world, particularly in places where agriculture is a major source of economic development **(Lal, 2015).** Deforestation, Excessive tilling, overgrazing, and excessive chemical usage are examples of inappropriate agricultural practices that degrade soil and result in problems including erosion, salinization, loss of nutrients, soil compaction. These methods damage ecosystems lessen the soil's capacity to sustain life, and eventually result in the loss of land used for agriculture.

Need of soil fertility restoration: Agriculture systems must use integrated soil fertility management to maximize crop production while minimizing soil nutrient mining and soil degradation, including soil erosion, depletion of nutrient and other adverse effects on soil health. The soil fertility restoration helps to enhance the soil health, beneficial environment for microflora of soil, underground water quality, agricultural production, and food security, conservation of biodiversity, balance ecosystem and results in sustainable environment. The restoration of soil also maximize the yield of crop indirectly economy of nation and minimize the natural hazards to the local communities. Therefore, during this globalization it is the need of time to optimize the various strategies and techniques to restore soil health.

Strategies and techniques to restore soil health: Soil fertility restoration include improving soil structure, beneficial microbial biodiversity, the amount of nutrients, and total carbon stores in the soil. Some of the strategies and practices to improve soil health are discussed further.

Reduction of Tilling:- Instead of plowing, reduced or no-till farming plants seeds directly into crop leftovers. Farmers either simply disturb a small part of the soil to sow seeds or leave crop leftovers and plant debris on the field's surface rather than thoroughly digging into the soil. This strategy has a number of advantages that can aid in the restoration of soil health. Modern agricultural techniques and Strategic tillage improves soil health, conserves resources, decreases erosion, and ensures agricultural resilience and sustainability by limiting soil disturbance, retaining organic matter, and improving fertilizer management **(Dixit *et al.*, 2024).**

Incorporation of crop rotation or cover crops: Growing a variety of crops in order to destabilize disease and insect cycles, optimize nutrients in the soil, and enhance soil structure is known as crop rotation. . Crop rotation also promotes a rich and diverse soil microbial community by changing the types of organic matter added to the soil. This cultivar promotes improved soil structure and fertility (Snapp *et al.*, 2010). Cover crops are defined as a "close-growing crop that provides soil protection, seeding protection, and soil improvement between periods of normal crop production" (SSGTC, 2008). In order to reduce erosion, increase organic matter, inhibit weed growth, and enhance nutrient retention, cover crops are sown during off-seasons. Cover crops may regulate several ecosystem services such as nutrient cycling, soil fertility, moderation of extreme meteorological events, pollination, and climate

and water regulation; in addition, Cover crops are also used as forage crops and have considerable effects on plant and soil biodiversity **(Quintarelli *et al.*, 2022).**

Addition of Organic Matter: Addition of Organic materials may improve drainage, soil resilience, irrigation efficiency, crop yields, and quality. It also help to improve the bIological, Physical and chemical properties of soil. Organic amendments, including animal manure, compost, bio solids, crop residues, and various organic by-products, are widely used to restore degraded soils by increasing soil organic material content. These amendments not only supply essential nutrients but also promote biological aggregation, suppress soil-borne pathogens, and improve soil's resistance to environmental stressors such as drought and heavy metal toxicity (Omokaro *et al*, 2024). There are various practices like crop rotation and cover crops also helps to enhance the organic content in the soil. The restoration of soil organic matter is the main factor for the sustainable agriculture.

Regular Soil tests: The soil test are important for the analysis of its nutrient content, deficiencies, porosity, salinity of soil, pH level, moisture content and other important parameters for the high yield. A complete soil test result helps farmers to solve imbalances to enhance soil structure, assist soil microorganisms, to optimize the fertilizers application, to make soil amendment decisions to enhance soil health and increase the crop yields.

Utilization of biochar as a soil supplement: Different strategies are used to improve soil nutrition for crop productivity. Biochar is a stable solid, rich in carbon made from organic waste material or biomass that is partially combusted in the presence of limited oxygen. The qualities that make up biochar vary depending upon the material that it comes from (feedstocks such as timber slash, corn stalks, manure, etc.) (https://surl.lu/wcbagk). The use of biochar as a soil amendment is also considered an appropriate tool for C sequestration, and an alternative to improve some soil properties (such as pH in acidic soils, cation exchange capacity and porosity), producing a decrease in bulk density, while it can also act as a microhabitat to soil microorganisms (Muñoz *et al*., 2016).

Application of Water management practices: Water management is essential for agricultural output in spite of global warming. The impact of climate change in agriculture causes water depletion, soil degradation, and agricultural production problems. Natural resource conservation and sustainable management, especially water management, have to come before strategic objectives. Water-saving and water-use efficiency schemes and strategies such as Awareness campaigns on Water, Sanitation and Hygiene (WASH), Training programmes on Sustainable Agriculture (SA) and Water Use Efficiency (WUE), and rainwater harvesting, water recycling etc. which are already functional must be become "best practices" of all water users (Hans, 2018). While reducing adverse effects on individuals, assets, and the environment, efficient, sustainable water management enhances the positive uses of water. Sustainable water management practices applications in agriculture helps to conserve underground water, enhance the productivity without disturbing environmental factors.

Implementation of strategies for the reduction of Soil Erosion: The various natural factors like rain, wind etc. responsible for the runoff of soil particles but the human activities like deforestation for construction purposes, unappropriated agricultural practices causes the soil erosion. The strategies for the reduction of soil erosion includes mulching, cover crop plantation, resurfacing slopes, slope soil protection structure application, fast growing vegetation at erosion sites. Damaged areas can be restored and protected from further erosion by using the proper soil erosion control strategies.

Conclusion

The restoration of soil important for the environment. The importance of soil restoration cannot be underestimated because it helps in food safety through increased crop yields, water quality and availability through improved infiltration and filtering, and reduces global warming through carbon sequestration. Additionally, it boosts ecosystem function, reduces soil erosion, and makes the land less susceptible to droughts and floods. In short, soil restoration is crucial for a better, more sustainable agriculture and environment for generations in the future. The sustainable agriculture is the foundation of stable economy and social improvement of nation. Therefore, this paper focused the importance of soil restoration for sustainable agriculture.

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Conflicts of interest

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