FUNCTIONS AND BIO-FUNCTIONS OF SOIL AND ITS RESTORATION

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ABSTRACT *The outer most layer of the Earth's crust or pedosphere is composed of finite natural body of soil which is influenced by the intensity of the prevailing soil forming environment. This protective and surficial cover having multiple roles in maintenance of stability in natural 'skin' through biotic and abiotic activities, is under constant threat of erosion, degradation and associated fertility loss from natural and quasi-natural forces. Overdose of chemical input not only spoil the soil in terms of physical character but also affect the wholesome microbial population. Soil organisms, the worthy integrant of bio-function plays a congenial role in breaking of organic matter and thereby formation of humus, recycling of nutrients, stabilization of soil structure with other physical forces, nitrogen fixation potentiality, promotion of plant growth, food quality and security maintenance. So, there is an urgent need of protecting the functions and bio-functions of soil through the initiation of environment friendly techniques and strategies to save this highly vulnerable cover and dependent floral and faunal kingdom.*

Keywords: *function, bio-function, pedogenic, organism, restoration.*

Aims and Objectives of the Study

The present study aims at

i) To point out the functions and bio-functions of soil.
ii) To sort out the threats to normal functioning of soil.
iii) To formulate effective restoration strategies to save this endangered but highly essential base of the Earth.

Introduction

Soils, the earthly outcome above the lithosphere have become its origin through pedogenic processes over millions of year through the known and unknown activities of a series of variations in weathering and transformations. This terminal product of parent material, landform, climate, biological activity and time continually undergoes development through multitude of processes.

Soils, the ensured base of most biotic communities, have evolved mostly in the event of interface with lithosphere, hydrosphere, atmosphere and biosphere. This mostly available and non-renewable resource is under constant risk of erosion and degradation. These unavoidable but controllable erosion events not only register 'on-site' hazards like decline of productivity, reduction of carrying capacity of ecosystem but also create 'off site' problems like eutrophication to hyper-eutrophication in drainage system and wetland, siltation in rivers, lakes, reservoirs etc. Trillion tons of fertility erosion takes place with billions of organic species in every year from every corner of the globe.

Structural orientation, textural setting, porosity, cohesiveness, permeability status and organic matter content mostly affect the soil loss phenomena. Fine soils are more erodible than the coarse one. More base minerals in a soil lead to greater consistency as these contribute to the chemical bonding of the aggregate. Stability of soil is also controlled by the type of clay and mineral present in it. Illite and montmorrilonitic groups of clay are less stable due to greater swelling capacity. Soils having less organic matter (<2%) are more erodible than that of higher concentration. Its cohesiveness helps to retard erosion and associated biotic loss. Only scientific management practices will help to mitigate this age old problems to minimize the loss for the benefit of teeming millions.

Soil Organisms: Type and Role

Soil organisms constitute millions of species that live in soil during the whole or part of these lives ranging from single celled bacteria, algae, fungi, protozoa, plants to small mammals which play an important role in maintaining fertility, structure, drainage and aeration of soil. A profuse diversity of organisms constitutes the "soil food web" which regularly interlinks plants, animals and environments.

The Editors of Encyclopedia Britannica have divided the soil organisms into five arbitrary groups as follows

i) The Protists including algae, actionmycetes and bacteria.
ii) The Microfauna which are less than 100 microns in length and usually feed upon other micro

organisms. Single celled protozoans, nematodes, tardigrades or eight legged invertibrates, rotifers do fall in this group.

iii) The Mesofauna includes larger and heterogeneous species that feed either on decaying matter, living plants or micro organisms. It includes mites, springtails, proturans etc.
iv) The Macrofauna covers a diverse nature of organisms such as potworms, slugs, snails, millipedes, centipedes, beetles etc.
v) The Megafauna constitutes largest organisms such as earthworms, mice, moles, lizards, snakes, gophers, badgers, hares and rabbits.

Soil organisms mostly have a beneficial role for the betterment of soil. These live along the region of available food supplement by root secretions, on humus, in litter, on the surface or in spaces between soil aggregates (Ingham, E.R. 1999). "Long-term experiments have shown that soils receiving farmyard manure had the highest microbial population, followed by soils treated with NPK" (Biswas, T.D. and Mukherjee, S.K. 2013).

Soil organisms mostly are in full play with availability of moisture and temperature. These perform the following functions

a) Biological activity actively involves in soil formation.
b) Hundreds of core of organisms grow and take shelter per square metre of soil and helps in fertility increment.
c) Soil organisms do perform in productivity augmentation.
d) Micro organisms often break complex organic matter of decaying plants and animals to make useful for further utilization of plants.
e) Soil organisms help in nitrogen cycle by breaking up of polypeptides, proteins and nucleic acids in its bodies and generate ammonium nitrates and nitrites which act as the building materials of plant tissues. These organisms also take part in sulfur cycle by breaking natural sulfur compounds to make these available for plants.
f) Micorrhizal fungi in soil degrade organic matter to form humus (Jeffries, P.2003). This formation again nurtures the soil organisms by providing food materials.
g) Soil organisms secrete polysaccharides, glycoproteins, gums which provide the cohesiveness of binding soil minerals and thereby help in formation of soil structure.
h) Organisms and organic matter help to maintain the pH level fit for the fertility increment.
i) Azotobacter, the free living soil microbes of aerobic nature fix atmospheric nitrogen in ammonium (NH_3) form to make available to living organisms (Postgate, J. 1998). Soil bacteria, rhizobia in association with legume roots can fix nitrogen as these have inability to fix it independently.
j) Organisms help to protect underneath roots from the root rot or other pest and disease inviting agents and often create a protective environment or rhizosphere along the living roots or form symbiotic or micorrhizal relationship with each other.
k) Prey-predator relationship among the organisms often helps to control microbial population boom.
l) In absence of micro organisms, soil will turn into hard, compact, unaerated, almost unploughable and unproductive lump.

Soil Functions

Soil, the earthly resource materials of life supporting system is often considered as the base of food security. This 'Skin of the Earth' interfaces with lithosphere, hydrosphere, atmosphere and biosphere. Soil with handful of lives perform manifold functions as

- Soil acts as the very essential base or medium for land plant growth and its proliferation.
- It affords the biological habitat of plants, animals, man and micro organisms.
- Its solid base helps to deep anchorage of plants roots to withstand speedy winds etc.
- Soil with its fertility and productivity provide the food supplement for the biotic kingdom.
- It has an inherent capacity to support biomass generation. Its volume depends on the types of soil, plant species and the prevailing environment.
- Soil acts as the store house of nutrients and allows it to transform.
- It helps to purify the environment, act as buffer and absorb toxicants, such as carbon etc. and thereby lessens these impacts.
- Soil body performs as the filter function with water and goes through with purification of water itself.
- It may be regarded as the 'Biodiversity Pool' with countless numbers of animal and plant species.

- Soil is the repository of water wealth.
- This 'skin' acts as the modifier of the Earth's atmosphere with continuous interaction.
- Soil organic matter helps to improve soil structure, moisture retention and root penetration capabilities.
- Soils lessen the scorching and chilling effects of sun and shades in summer and winter.
- It helps to supply necessary carbon and nitrogen to organisms.
- It yields raw materials ranging from food stuffs to industrial supplement.
- Well drained soil mostly helps to restore the fertility status.
- This outer most cover serves as the archaeological and geological archive.
- Soil allows itself as the foundation or the base of developmental construction.

Threats to Soil

Soils regularly face threats from natural, quasi-natural and human induced activities, although it has immense importance for the survival of human kind. The productive top soil regularly goes through manifold kinds of loss, damage and temporary or permanent obstruction from being potentially harvest return. Various types of threats may be recognized as here in under

- **Soil erosion** or wearing of top soil is the continuous loss event be it geologic or accelerated type as water erosion, wind erosion and tillage erosion. Soil is mostly eroded by water as sheet erosion, rill erosion, gully erosion, slip erosion and stream bank erosion. Falling raindrops, prominent and alternating wet and dry seasons of the year usually help to accelerate water and wind erosion. Soil erodibility factor... "relates the rate at which different soils erode depending upon their inherent soil properties"(Oswal, M.C.1994).
- **Deflation** process constitutes the erosion by wind of land and or soil with loose unconsolidated materials from dry plain land surfaces. Wind speed, soil particle size and the eddies formation mostly control the distances covered by transportation.
- **Landslides,** the often devastating geo hazardous phenomena cause havoc to the soil structure along with plants and animals therein be it in forms of slide, fall, debris flow or mud flow. Gravity, lack of cohesiveness in the event of devoid of vegetal cover, slope increment due to the unscientific construction activities often cause soil threat.
- **Bogging** is a wetland situation with accumulation of decayed plant material enriched acidic peat. In warm climates, excess of precipitation in low lying areas and in cold climates thawing event in the local basins often disrupts the normal performance of the soil.
- **Salinization** is a process of increasing water soluble salt content due to mineral weathering, oceanic salt water intrusion, increasing aridity or excessive irrigation practices. It affects osmotic potentiality which inhibits the uptake of water by plants. Poorly drained soils often face this problem which requires adequate flushing with rain water for correction.
- **Soil organic matter removal** often causes a huge blow as this with multitude of components regularly enriched the fertility status of mineral soils. It enhances the plant production potential by managing physical and chemical properties ranging from structural suitability to water holding capacity, root penetration capability and soil pH maintenance. So any loss or removal of soil cover is obviously results in curtailment of available soil organic matter.
- **Contamination / Accumulation of adverse chemicals and compounds** as industrial solvents, pesticides, untreated sewage, heavy metals, fly ash, e-waste, hydrocarbon etc. regularly pollute the soil and cause a grave threat to the soil productivity and crop quality.
- **Desertification** is the process of formation of once productive soil or land surface into a barren, desolate and often uninhabited tract. Climate change, salinization, over exploitation of water, soil, forest, fertility and other natural resources constitute the factors of desertification.
- **Fertility erosion** induced chemical input to mitigate the production gap may cause a huge blow on soil as well as total land quality.
- **Sand encroachment** refers to the coastal as well as inland sand flow that covers up the productive soil and thereby inhibits the production efficiency. Windblown sand deposited land needs reclamation or dune stabilization management to get rid of this hazard.
- **Soil Tillage** by conventional or erroneous methods of farming which often turn over and weakens the soil aggregates enhances not only the soil erosion but also dwindle down the amount of nitrogen and number of soil organisms.

- "**Deforestation** intensifies the runoff to rivers, and the increased runoff carries away larger quantities of nutrients from soils." The Mississippi river of USA "...alone carries away to the ocean 62 thou t of phosphorus, 1 mln t of potassium, over 22 mln t of calcium and over 5 mln t of magnesium every year (Zonn, S.V.1986).
- **Soil sealing** refers to mostly permanent impermeable developmental covering on the land in the form of metalled roads, buildings, factories and so on. It not only makes a bar on further utilization of that soil but also accelerate the risk of flood, drought, contamination etc. by enhancing surface runoff and retarding the ground water recharge.
- **Soil removal** for brick making, mud wall building, potteries or for only landfills cause loss to the soil.
- **Desert Crusting** refers to the formation of gypseous, carbonate-gypseous, carbonate-silicious, silicic and clayey materials in the surface and subsurface. It is barren and occasionally supports rare growth of rare growth of grass (Zonn, 1986).
- **Soil compaction** is the air out from a soil mass with the force or pressure applied on it. Ongoing heavy vehicles or bullock carts, hoofs of animals often cause the unairy condition of soil which prohibits soil erosion due to compactness and also restricts ploughing and plant growth.
- **Overgrazing** not only accelerates soil erosion but also inhibits the accumulation of litter and cause compaction and soil degradation. It thereby restricts tall and healthy grasses. Overgrazing often leads to desertification also.
- **Monoculture** often causes heavy productivity loss due to continuous uptake of certain elements and induces soil degradation by increasing soil pH.
- **Mining** activities of ores, minerals, coals, rocks etc. cause soil removal. Again, artificial hole, pond, ditch or lake formations cause soil erosion and contamination by related dumping activities.
- **Shifting cultivation** is often practiced in forested regions of the developing nations. This slash and burn method reduces the forest, animal lives and also deteriorate the soil cover.
- **Cultivation in marginal lands** which are narrow and often highly vulnerable to erosion should not be practiced, and areas of steep slopes, shallow sandy soil must favoured with inclusion of short heighted and less voluminous green belt.
- **Soil death** is caused by laterite formation (Zonn, S.V. 1986). Harder rocky layers absolutely prohibit agriculture.

  Land degradation is "also results from insufficient correlation among the different land utilization types, agricultural and urban, within an area." (Vink, 1975).

Measuring Techniques of Soil Loss

Soil erosion is a menacing problem worldwide. The gradient or slope of the land, adhesiveness, humus content, porosity and permeability and the velocity as well as the intensity of external forces such as blowing wind or flowing water determine the nature of erodibility. Again bare surfaces should be kept under various measures of combating this age-old phenomenon which include Best Management Practices (BMPs) by arresting the erosion including factors in root. Although, "Soil erosion control techniques are theoretically simple and easy but practically dirty, tough, time-consuming, laborious, controversial, and costly…One technique can be successfully applied to reduce the soil erosion on a site but success cannot be guaranteed on another site if it is not modified to reflect site specific characteristics" (Choi, J. et al.2005). Universal Soil Loss Equation (USLE) experiment may also give good results in measuring the soil loss by erosion (Ciesiolka, C.A.A. et al. 2004).

Loss of soil with its with its fertility removal may be monitored in different categories of land having different slope grade, although homogeneous slope of lesser degrees often exhibits good results. Again bare rock surfaces are highly prone to erosion in comparison with the covered surface. But it is very near to impossible to measure the actual count of eroded sediment from anywhere else as these are soluble and transported into the endless destination as solution. Runoff Plot Test, Runoff Plot Erosion Test and Field Size Erosion Test often demand sophisticated equipment to measure and monitor, although there is more likely a possibility of varying result due to storm intensity difference.

Soil erosion loss may also be monitored with the application of simple technique using few long nails piercing deep underground. These should be kept intact from any artificial pressure on it. The erosion mass should be measured after stormy events with thickness scale. Comparative study may be undertaken with covering on few patches by impervious sheet.

Restoration Strategies

Soil, the nurturing medium of biotic world needs to be urgently protected from any sorts of decaying activities

for safeguarding the human civilization. Many conventional methods may be applied with the nonconventional and experimental techniques as here in under

- Rain water harvesting practices for timely use to lessen the alternating wet and dry spell to accelerate erosion. It helps to keep intact the ground water to avoid desertification phenomenon.
- Promotion of local catchment basin or wetland to collect the excess of overland flow for local use and ground water recharge.
- Improved drainage system will be helpful in retaining top soil, otherwise top soil mass will be removed heavily throughout the entire region..
- 'Keyline Design' technique may be useful for soil /water conservation and sustainability attainment in agriculture.
- 'Geotextile methods' of woven, non woven and coir types may be used to stabilize soil.
- 'Exhausted' or 'tired' soils with frequent mono-cropped cultivation practices are highly prone to degradation. "Continuous cultivation of a single crop over years on the same site causes accumulation of a particular group of microbes which dominate over the others. Crop rotation disturbs the unfavourable population balance" (Biswas, and Mukherjee, 2013). Crop rotation and fallowing techniques make useful for restoring healthy condition of soil and thereby helps to arrest fertility erosion and consequent soil loss phenomena.
- Stabilization of slope through management initiatives will help to reduce the landslide hazard.
- Green manuring practices through green manure crops such as Sannhemp, Dhaincha, Urd, Mung, Khesari, Berseem etc. may help in adding nitrogen instead of applying it through chemical input and thereby helps to arrest soil loss (Sahai, V.N. 2011).
- Indigenous crop varieties which often use less water, low input, and nil pesticides may prove suitable to check water loss, maintain biodiversity in the crop land, stop soil pollution and thereby retard soil degradation.
- Controlled grazing often proves conducive as it helps to add biotic waste from animals and ensure balancing growth. But, high grazing activities largely help to accelerate soil erosion, soil compaction and so restrict further growth.
- Prohibition of use of pesticides may be helpful to control soil pollution phenomenon. To combat this pest outbreak, initiation of antagonistic pest may be highly recommendable.
- Grass cover is highly suitable to arrest the threat of soil loss event. It not only binds the soil but also enhance the ground water percolation by checking the free runoff unlike in the bare surface.
- Erection of retention wall with pervious materials such as stone etc. helps to percolate water but not sediment flow in an uninterrupted way.
- Terracing in hill slope may be an effective barrier of soil loss.
- Contour farming practices which slow down the pace of flow helps to slow down soil erosion.
- Mulching activity is useful to conserve moisture and soil.
- Afforestation and reforestation measures are age old techniques to stabilize slope / soil / land etc.
- Organic farming enhances the moisture retention capacity, soil aeration and thereby prevents it from degradation.
- Land use Land cover practices should be regulated with the slope category of the land. Slope under 5^0 only be used for agriculture to minimize the risk of soil erosion.
- "Land development and soil conservation projects cost time and money, and these are not always readily available, while the schooling of farmers in better methods of landuse ...." may be highly judicious (Vink, A.P.A. 1975).

Other means may also give good results, such as "… forest massifs, anti-ravine stands; as well as radical changes in the ratios between ploughed, pastoral and forest lands" (Zonn,1986).

Green manuring through green manured crops such as *Sannhemp, Dhaincha, Urd, Mung, Khesari, Berseem* etc. may highly help in adding nitrogen instead of applying it directly through chemical input and thereby helps to arrest soil loss (Sahai, 2011).

The following follow up may be highly helpful to minimize soil loss events:

Curtailment (of slope/steepness induced activities)

↓

Replacement or covering (the barren field into grassland or mixed forested land)

↓

Leave alone

Conclusion

Soils, the topmost precious earthly materials of the Earth are constantly under tremendous pressure of waning through degradation, erosion, pollution and fertility erosion processes. Dwindling returns will be manifested in environment, economy and food supply. The worldwide erased out great civilizations of the past, always bear the imprints of disastrous fate of scarcity and ultimate collapse probably by the loosing capacity of material outcome of the land. The same tune is under high volume in almost in every country where abolishing primary vegetation tends to damage the fertility, floral and faunal community in large quantity and loose more than 30% of global land surfaces during the past few decades. The major change over in farming practices, crop selection, afforestation, grass cover encouragement, dependence on organic manure and consciousness generation through environmental education will be the effective measures to regain its formal position.

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