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Soil and Human

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Abstract

By "no soil" is meant that there is no sustenance of humans. We take birth on soil, live on soil, walk on soil, die on soil and finally vanish in soil. Soil is synonym to Soul with immense spiritual values. Our civilization has flourished because of soil. Soil is the biggest biodiversity reservoir. Our health, culture and social behaviour are dictated by soils. Soil in continuum is sounding Vasudevakutumbkam. Indians worship soil as Holy Mother. However, demand for this holy mother is pressing with increasing human population and shrinking trend of agricultural land areas. Even though humans in general are consciously trying to care for soil, most of the time, human interferences remain imbalanced as well as disastrous causing ecological instability. This chapter discusses on major human interferences with diversified types of soil that often cause imbalance in equilibrium on way to restore sustainability due to missing linkage in reliable management options and technology generation. Men are wandering in space to find water, air and rock with one of missions to discover soil for future shelter other than this earth. Soil is a complete prescription for livelihood security. In fact, human exists because of soil and both work in symbiotic relationship, but the driving force in restoring such unique partnership often rests on humans because of their capability in taking correct decision with intelligence and creativity. Soil biotechnology is a new area of research covering wide range of possibilities for protective medical treatments even. Soil battery is another emerging field of research to look for clean energy source..

Keywords: Soil and Soul; Holy mother; Population pressure; Soil human interactions; Disastrous consequences; Symbiotic relationship; Soil biotechnology and biodiversity

Introduction

Soil being so vital for humans is least credited for its life supporting functions. However, the 2015 International Year of Soils has been committed for increasing awareness and understanding of the importance of soil for food security and essential ecosystem functions. As an infant depends on mother for his or her food so is the humans on soil, the only difference is that as the infant grows, he or she gets rid of dependency for physical need on his or her mother, but we humans, even after million years of evolution, depend so much on soil from birth to death. A man will die but the carbon will not; its career does not end with man. It will return back to the soil, and then a plant may take it up again with time, sending it again and again on a cycle of plant and animal life.

Soil or human is virtually of least meaning if either of two exists in isolation, without one another. A crop is merely a product of the joint efforts of a man as well as a soil. Any blame upon man is merely possible because of the fact that man is conscious, intelligent and decision maker of such unique partnership that can be referred to be symbiotic, since the soil has significant relevance in almost all the necessities for the survival, nourishment, shelter and livelihood of human beings. Soil is not dead, inert or dirt, but a factory where raw materials are transformed and converted into finished products. When a soil is referred to as a tool in the hands of man to accomplish something with, it is not as a simple tool such as a saw or plane, but as a highly organized tool as a factory or an engine or an animal [1].

Indian civilization has flourished and sustained itself over thousands of years because it revered the soil as sacred and inviolable. Ancient Vedic people did have immense respect for soil as Mother Earth. The Atharva Veda invokes the prayer to prithvi, the Earth:

"Let what I dig from thee, O Earth, rapidly spring and grow again.

O Purifier, let me not pierce through thy vitals or thy Heart"

It is only India where plants, trees and animals including soils are worshipped. The soil of India witnesses the growth of one of the oldest civilizations in the world the Indus Valley Civilization.

It is the soil that dictates how survival, nourishment and livelihood of mankind are moving. Human population particularly in India is continuously increasing, while land is shrinking because of diversion in non-farming activities. Per head farm area has already become tiny. As a consequence, the equilibrium between man and land is imbalanced that results into pressing demand of land in India. Land is being used thus intensively and, more often, carelessly to meet the alarming people's demand. This situation appears in over exploitation of soil as a finite resource for meeting infinite number of demands for humans and societies. The Chapter is an overview of the interactions between soil and humans under current scenario in India based on services rendered by soil as a natural resource since ancient civilization.

Soil and Human Evolution

It is well documented that human evaluation took place in African continent. Based on paleoanthropological discoveries in Ethiopia, Kenya, Tanzania, Uganda and Zaire, the African rift valleys are indeed considered the "cradle of mankind", that is the place where human species evolved and diversified in the last million years. The Awash valley is the early home of human ancestors "the hominids". It is one of the best open-air museums in the world in which the early direct ancestors of human being lived before millions of years. Moreover, it is the place of early human technologies "the Stone Age technologies" for the handy man lived there before millions of years. The archaeological sites of the Awash and Omo valleys, the Konsogardulla, Melka kontre etc are the live witnesses of this reality. The human evolution could be traced back to the palaeontologists with fossils of 6 million years old, recovered from Chad, Kenya, and Ethiopia belonging to the era of Ardiplthicus, the first phase of human evolution. It is followed by the famous Australopithecus era, (around 4.1 million years upto around 1.3 million years ago). First record comes from Kenya and Ethiopia and is known as Australopithecus anamensis. Our human ancestors had been walking on this planet for at least two million years before *Australopithecus afarensis*, or the famous skeleton found in the Hadar cave area in the deep Afar of Ethiopia, the Lucy's group.

Ardiplthicus era was followed by the Homo or the genus Homo. Homo erectus with bigger brain, using stone tools (oldest record 2.3 million), were found closely identifiable with human race and that is from Ethiopia. Homo erectus is the species that we can find almost in all parts of the old world, almost about 600 to 500 thousand years ago and we find them in Europe, Asia and Africa. Later, about 165 thousand years ago, the size of brain ever grew, which is call the Homo sapiens, the first species, they went down around 100 thousand years to the "Middle stone age" [2]. The story went on further into "Later stone age" and so on. Till the time, dependency of humans on soil was indirect as they were the gatherers and hunters. Groups were formed, communities were taking its initial shapes and the concept of territory and ownership of territory was taking its rudimentary shape. The major breakthrough took place only about 20,000 years ago, when humans started cultivation. Subsequently, they shifted to fertile land to grow crop for survival. It was a paradigm shift towards land and soils.

Science Journal described that races in India have been broken up pulverized, kneaded by conquerors. Dravidians succeeded negroids, and there may have been Malay intrusions, but Australian affinities are denied. Then Aryan and Mongol succeeded forming the present potporri through conquest and blending [3]. Bates [4] compiled the race, caste and tribes in central India.

Also, the human race migrated from African origin places to highlands of central Asia. Migration was continued to different corners of the world probably due to geological disturbances followed by land and soil degradation resulting in scarce vegetation for their shelter and survival. It is believed that some homo sapiens (human group) were climbing down from central Asia to the Indus valley and settled there where they subsequently developed vedic civilization with a well-developed culture being supported by prosper agriculture-based economy. First protected village and further walled cities like 'Harappa" and "Mohan-ja-doro" were created. Some of them migrated further to deep down into the forested land of the Ganga plain possessing fertile alluvial soils and a series of cities and kingdoms came into existence. Simultaneously, some might have migrating to southward in the fertile valleys of the Narmada and Tapti while others further down to the coastal plains of Konkan and subsequently to the eastern coast through the Godavadi and finally touched the southern extreme of Indian peninsula. A group of humans travelled far east up to the Kamchata peninsula and further entered into American continent. This generalized sketch of how humans with their evolution from Ethiopia and adjoining African territories got migrated to other parts of the earth in search of food and water for their survival would signify how soil is valuable to humans since evolution. Though they travelled through all terrains, tough and arduous, however, they settled and grow only on the fertile alluvial terrains.

The fertile soil was sufficiently capable to produce surplus food and so the human groups were made involved for other specialized jobs like carpenter, potter, mason, weavers, iron smith and so on. Such arrangement then led to the evolution of "Society" and subsequently of "Gram" representing agrarian society and "Pur" for urban society as translated with the birth to the Vedic Civilization in Indus valley region of Indian subcontinent. It is apparent that soil has remained silently but actively responsible behind growing human civilization.

Soil and the Soul

India is a land of 'Guru', as enlightened with spiritualism, wisdom and humanity. The soil or the 'Bhumi' or 'Mrida' is often meant for "soul of infinite lives". The soul is basically a spiritual concept behind the existence of one's identity with the surroundings. Every individual or creature does possess a "Soul" that is believed to drive and control the system of life, such as power of conceiving, listening, thinking, creating, cultivating, ploughing, etc. If we translate the concept of soul to some physical arena, we will see that 'soil' is the one that fulfils the basic essence of a 'soul'. Soil is the basis for all terrestrial lives including humans. That is why the Indians prefer to sit and walk on bare soils for sustaining

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the hidden forces, energy, spirit and consciousness. Even the most vital ingredients of human viz. air, water and food are under the influence of soils. Although the soil is beneath our feet, it takes every cares of our survival, nourishment and even livelihood. This is why we worship soils in different forms and manners in different parts of India.

The worship is broadly a way to express solemnly the inner feelings and promises of life to one who cares. A small child says his inner feelings to his mother, because it is mother who cares for him. The Sita of Valmiki's Ramayana is believed to have been discovered in a "furrow", when her father King Janak was ploughing the field (soil). As cited in the Rigveda (4:57), the Sita is known as the Earth Goddess to bless the land for good crops. However, Laxmi Mall Singhvi in a link stated that the destruction of the life sustaining environment is a result of ignorance, greed and disregard for the richness of all living things and as a result of which the future generation is subject to inherit a dead world.

Further, as Lord Mahavira proclaimed a profound ecological truth, 'One who neglects or disregards the existence of earth, air, fire, water and vegetation disregards his own existence.' Even "The Buddhist Declaration on Nature" states that every cause follows the consequences and effects. The Vedic Hymn to the Earth, the PrithviSukta in Atharva Veda, is unquestionably the oldest and the most evocative environmental invocation, wherein the Vedic seer solemnly declares the enduring filial allegiance of humankind to Mother Earth: 'Mata BhumihPutrohamPrithivyah (Earth is my mother, I am her son). In the Atharva Veda, this ecological theme is so very clear: "Mother Bhumi (Mother Earth), may whatever I dig from you grow back again quickly, and may we not injure you by our labour." There are hymns to Mother Earth--BhumiSukuta: "Earth, in which the seas, the rivers and many waters lie, from which arise foods and fields of grain, abode to all that breathes and moves, may she confer on us her finest yield." (Atharva Veda XII 1:3). So, human's existence ultimately rests on the "state of soil".

Major population in India is Hindu who believes on cremation i.e. burning after death except for pregnant women, children, saint and babies. Cremation is common in Buddhism, Jainism, Sikhism and few catholic with differing ideologies. Hindus believe soul being indestructible. It is believed that burning the dead body releases the spirit from the body in the form of flame that signifies the creator, Brahma. Cremation is thus seen as important for the safe transmigration of soul. In other religions, dead body is normally buried. Often, sands are supposed to be inert and inhibit microbial growth and risk of contamination and may be preferred. In fact, human body is a mass of five elements such as Agni (fire), Jal (water), Prithivi (earth/soil), Aakash (space) and Vayu (air), wherein Prithivi or soil has vital role to play in the existence of life.

Soil, Culture and Civilization

The oldest Indian Upnishad described "soil" as "Bhumi" meaning the land. The soil was the main yardstick enabling the human civilization to flourish on long term basis. Obviously, human was wondering in search of a land having productive soils with assured irrigation and easy transportation around a river basin. Indus river in the north-west (now in India and Pakistan) was the main river, where the earliest civilization in India flourished for nearly one thousand years. Even the prehistoric site of Mehragarh in Baluchistan is the earliest Neolithic site in the north-west Indian sub-continent, dated as early as 8500 BCE [5]. Another important river in ancient India was the Ganges, wherein settlements developed on their banks from as early as prehistoric times. Soil is thus responsible for survival, nourishment and livelihood of entire human beings. It is a natural resource like sun and others. If sun is a source of energy for us, the soil appears as a medium for getting food, fibre, fuel, fodder, forest, flower, furniture and floor in order to enable human beings for access to quality meal, clean water, pure air and comfortable livelihood. We stand on soil, which is beneath our feet and henceforth we often overlook its values. However, the method for stabilization of soil was first developed in India [6].

The sun is far away from our reach, whereas soil is in close proximity to human beings, where we live and let the soil work for our existence. Through all physical, chemical, biological and mechanical manipulations in open system, the soil does not take any rest and that too because of human interferences. The soil being a natural resource is not static and exists in dynamic state in the environment. The urban soils are nothing but the outcome of extreme human interferences in the city area.

Human creation was depicted by different forms of art. Painting was prominent among them. Soil was not only used as the base but also used to prepare colors. From farms to houses, from floor to courtyards, from pots to bricks and tiles, from prayers to rituals and from birth to the death, it is the soil which has always been the part of our life in Indian culture.

Figure 1: Pottery.

In India, soil is not just the part of socio-economic and religious-cultural setting but also a tool for expressing their creativity in the form of "Art" (Figure 1). Ranging from a rural village woman depicting her creativity on the earthen wall of her hut or house to the rural artisan manufacturing earthen pots, toys and idols to the traditional painters doing big decoration on the festivals, soil is used as the basic element of traditional colors (Figure 2). In this context, traditional Madhubani art of Mithalanchal in Bihar, vari-

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ety of rangolies made at the doorstep of houses (Figure 3) or the temples in different parts of India, great painting of Ajanta caves and on the walls and curtains of monastery of Ladakh, Sikkim and Arunachal Pradesh including the monastery of Lahul and Spity are the masterpiece of arts where soil as a base for the colors have been used. The famous artist from Kerala, Raja Ravi Verma (1848-1906) is honored as one of the greatest painters from the Indian soil and known for his portrays of scenes from the epic sagas of the Mahabharata and Ramayana. Ravi Varma had been using the indigenous paints made from leaves, flowers, tree bark and soil which his uncle Raja Raja Varma used to prepare for him [7].

Figure 2: Idols.

Figure 3: Culture.

However, among the cultural practices, idol immersion in the water bodies after celebration is common throughout the country. Idol is lavishly decorated with different paints such as varnish, paints, water colors and colored papers and foils etc. Mercury, cadmium, arsenic, zinc, chromium and lead are the common heavy metals present in such paints. The floating materials released through idol in the river and lake after decomposition result in eutrophication, increase in acidity and heavy metal concentration [8]. Heavy metal pollution caused by idol immersion can damage the ecosystem as it kills fishes, damages plants and blocks the natural flow of the water causing polluted water stagnation. Water from these sources is also used for irrigation particularly in the vegetable crops around the urban areas. Electrons present in soil and earth help to enrich immune system in our body and increase the oxygen level while walking barefoot. Nerves of the feet are stimulated, and cardiovascular system is improved by walking barefoot [9].

Soil, Dispute, Conflict and War

Soil as a basic resource plays an important role in running a family, society or a nation smoothly in harmony. However, the situation, contrary to this, instigates inter-family and intra-family disputes, resulting subsequently into conflicts between the administrative units within a nation and even a war between the nations. It is a common understanding that litigations occur mostly for three main issues viz. money, women and land, but the land (jameen) is the most common issue behind dispute. In India, joint family is not declared divided unless the ancestor's land is legally distributed in black and white. In many instances, soil quality of land becomes an issue of conflict in the family causing disputes. During flood in Diara and Tal land in Bihar, civil wars are common to acquire lands after flood recession [10,11].

India is a peace-loving nation and believes in Vasudevkutumbkam as well as Satyamevjaiyete. Our neighboring nations must learn from the essence of soils to restore humanity, brotherhood and symbiotic mutual cooperation for the welfare of their citizens. If two nations suffer from conflicts, the soils in affected areas remain unutilized by the farming communities in either of the territories. This leads to unrest and violence among the common public in the affected areas. The 1992 Rio declaration states, "Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary." During such wars, besides killing of men and animals, the soil, air and water are severely polluted because of destroying impacts of the uses of weapons and chemicals including destruction of oil fields. War is a curse to soil, if warfare is on ground. Fuel, chemicals and nuclear contamination ultimately cause a typical soil infertility that is irreversible for a long period of time. Such infertility in the affected soils may be comparable to even a cancer disease. The soil in such a disputed land unit suffers from proper care and management and is subject to severe degradation. Such situation leads to a shift towards poverty, and threatens the livelihood leading to illiteracy and civil war subsequently.

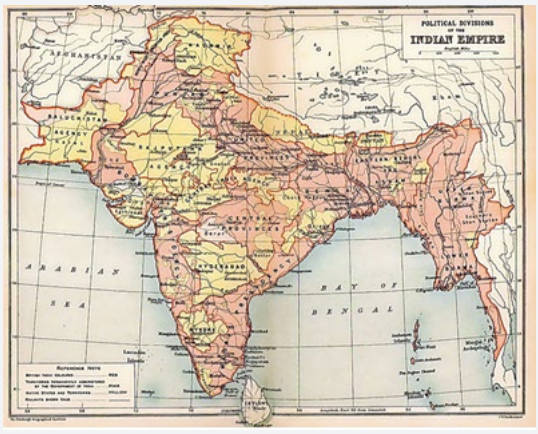

Figure 4: Pre-Simla British map published in 1909 shows the so-called "Outer Line" as India's northern boundary [13].

In Sino-Indian war of 1962, a disputed Himalayan border (Figure 4) was the main pretext for this war. There had been a series of violent border incidents after the 1959 Tibetan uprising including several north of the McMahon Line, the eastern portion of a Line of

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Actual Control proclaimed by Chinese Premier Zhou Enlai in 1959. Such disputes are otherwise related to warfare and soils do suffer extensively. Government of India through Ministry of External Affairs in Rajya Sabha presented a generalized detail on 22nd November 2011 (question number 27 by YS Chowdary) that Pakistan has been in illegal occupation of around 78,000 square kilometers of Indian territory in Jammu & Kashmir, while China to be in illegal occupation of approximately 38,000 square kilometers in the Indian state of Jammu and Kashmir. Such illegal occupation of land area directly signifies the restrictions in productive uses of soils [12].

Soil and Human Health

Soil is intimately related to human health. The origin of food chain is soil and ends in human body through plant or animal. Mishra and Richa [13] have recently reviewed on scope of type specific soils as well as clays in medical treatments. The heavy metals of greatest concern for human health include As, Pb, Cd, Cr, Cu, Hg, Ni, and Zn [14]. It is well known in present context that the human health is virtually a finger print of soil health and one must try to keep the soil healthy, but he finds compelling situation to overlook even the known management issues. This is because the current demand from soil is increasing day by day with heavy pressure forcing soil resources to get deteriorated. In the modern world, we recognize that soils have a distinct influence on human health [13].

Approximately 78% of the average per capita calorie consumption worldwide comes from crops grown in soil, and another nearly 20% comes from terrestrial food sources that rely indirectly on soil [15]. Soils are also a major source of nutrients, and they act as natural filters to remove contaminants from water. However, soils may contain heavy metals, chemicals, or pathogens that have the potential to negatively impact human health. A mere 11 elements constitute 99.9% of the atoms in the human body. These are typically divided into major and minor elements. The four major elements, H, O, C, and N make up approximately 99% of the human body, and seven minor elements, Na, K, Ca, Mg, P, S, and Cl, make up another 0.9% of the body [16]. Approximately 18 additional elements called trace elements are considered essential in small amounts to maintain human life. Out of those, only around 29 elements are considered essential for human life, 18 are either essential or beneficial to plants and are obtained from soil, and most of the other elements can be taken up from the soil by plants [15]. A more recent health concern includes pharmaceutical waste derived from antibiotics, hormones, and antiparasitic drugs used to treat humans and domestic animals [17]. However, there is need to develop a systematic approach in India on soil and human health.

Soil is the biggest biodiversity reservoir. It contains bacteria and fungi which are the source of enzymes as well as other molecules with considerable industrial and pharmaceutical values. In fact, major antibiotics are derived from soil bacteria. Nowadays, metagenomic approach is being applied for extraction of bacterial DNA for sequencing on way to establish Metasoil DNA bank [18]. Selman Waksman first used the word antibiotic as a noun in 1941 to describe any small molecule made by a microbe that antagonizes the growth of other microbes. From 1945-1955 the development of penicillin, which is produced by a fungus, along with streptomycin, chloramphenicol, and tetracycline, which are produced by soil bacteria, ushered in the antibiotic age [19]. India must look for such opportunities in type specific soils in relation to human health. Soil biotechnology has brighter future than ever. Besides, efforts being made to develop soil battery opens avenue to look for clean energy source in days to come.

Soil and Human Interactions

Mahatam Gandhi often used to say, "There is enough for everyone need but not for everyone greed." The concept of development either at family or at the nation level is now centered at the economic growth and this leads to the race of achieving the 'commercial production'. In such race, our soils have been exploited exhaustively without caring for sustainability. It is true that there would be no human existence without soil. However, anthropogenic interferences with soils lead to interactions in multidirectional facets resulting in certain negative impacts on soil qualities and characteristics of vital concerns. A selfish or excessive desire for more than is needed from a soil is disastrous.

Over 200 years of industrialisation have caused soil contamination to be a widespread problem in Europe. It is well documented now in India too that air and water pollution can have negative impacts on human health, but the impacts of such soil pollution on our health have had a much lower profile and are not so well understood. Farmers more often use the term 'soil health', which is similar to the term 'soil quality' used by soil scientists and researchers. A healthy soil has several physical, chemical and biological properties in definite balances in order to perform the defined functions. Soil needs to incorporate adequate organic matter, have a good structure, and should be home to a diverse mixture of organisms. Such properties allow the soil to carry out important functions and may be achieved in a natural setting by a soil attaining equilibrium with its surroundings, or in managed settings by human intervention to improve the soil's health. Agricultural soil health is linked to human health, as poor soils yield fewer crops with decreased nutritional value. Healthy soils also limit erosion and help to improve air and water quality [15].

As regard to the routes from soils to human intake, soil can enter our bodies via three main routes viz. direct eating, inhalation and through the skin. Eating soil directly (geophagia) is a rare but surprisingly unique practice among children under three, while playing outdoors. It is commonly believed that direct ingestion is the most important pathway for human exposure to soil contamination, although other specific pathways have some importance in certain situations. Working with soil often releases particles into the air that may be inhaled by farmers, farm workers and others nearby. Absorption of muddy soil or clay through the skin tends to

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favour more volatile, organic compounds. In indirect contact, soil contaminants may move from soils into ground or surface water, leading to contaminated drinking water. They may also be taken up by plants which are subsequently consumed, either by humans or by agricultural livestock, causing contaminants to enter the human food chain. High levels of arsenic in drinking water supplies are often another significant indirect result of soil contamination. Arsenic may also be naturally present in groundwater. If a chemical accumulates in tissues and reaching the critical toxicity level, it is harmful. Factors that are relevant in this case are the body's rate of elimination (by metabolism or excretion), and the overall 'body burden', the quantity of chemicals stored in body tissues [20]. Heavy metals occur naturally in rocks and in soils too in variable amounts. The heavy metals as health risks includes Arsenic (As), Lead (Pb), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni) and Zinc. Conversely, cadmium, lead and mercury have no known biological function and are toxic to humans. Soil acts as a repository for many heavy metals that human activity releases into the environment. However, the soil itself may then present a risk to those who live or eat crops grown on it [21]. Soil is truly a protective medical tool to keep human healthy. Human activities viz. farming, mining, smelting, industry as well as driving vehicles or burning fossil fuels all contribute to the burden of heavy metals in soils, as does our disposal of materials containing heavy metals, a long list which includes municipal waste, paint, electronic waste, and sewage [22]. Much of the evidence for the long-term effects of arsenic on human health comes from southeast Asia where there is a natural belt of arsenic-rich alluvium or sediments which were deposited millions of years ago in the Bramaputra and Ganges river basins. Bangladesh, parts of India, Myanmar and Nepal are all affected. An estimated 30 million people may be at risk from arsenic-related disease as a result of contaminated water in the region [23].

Sources of arsenic exposure includes

a. Natural routes viz. volcanic activity, minerals dissolving into groundwater, exudates from vegetation, and windblown dust.

b. Human activity, such as mining, metal smelting, fossil fuel combustion, pesticide production and use, and treating timber with preservatives.

c. Remobilization of historic sources, such as mine drainage water.

d. Mobilization into drinking water from geological deposits, e.g. by drilling wells [24].

Cadmium enters agricultural soils from the atmosphere and from application of phosphate fertilizers and sewage sludge. In heavily contaminated areas, re-suspension of dust can cause a substantial proportion of crop contamination and human exposure via inhalation and ingestion [25]. Industrial emissions are important sources of lead contamination of the soil and ambient air, and lead may also be ingested from atmospheric air or flaked paint that has been deposited in soil and dust, raising blood lead levels. At least 459 people died in Iraq, for example, when flour was made from grain treated with a fungicide containing mercury in 1971 [26]. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning [27]. Soils across the country are accordingly in-secured in terms of safety, productivity and sustainability. Soil degradation reduces crop yields by increasing susceptibility to drought stress and elemental imbalance [28].

Shifting cultivation and deforestation

Human induced deforestation is a serious problem across the country, particularly in the hilly and mountainous areas. Deforestation is conversion of forest land to other uses, while degradation refers to reduction in productivity and/or diversity of a forest due to unsustainable harvesting, soil erosion, removal of nutrients and loss of biodiversity and soil organic matter [29]. Around 80% area of India was forested during 3000 BC [30,31]. However, subsequent invasions changed entire landscape. First era in deforestation was shortly after absorption into British Empire [32]. The 1894 British Forest Policy accorded priority to commercial exploitation, state custodianship and permanent cultivation. Second major deforestation was in 1940s with demands of World War II and transition to independence for India and Pakistan in 1947 [33]. The National Forest Policy 1952 envisaged increasing forest areas to one third of the total land area but was difficult to implement. Report for post 1980 period indicates that rate of diversion of forest to non-forestry activities declined to around 15,5000ha per annum as compared to 150,000ha per annum prior to 1980 [34]. Total area under forests in India has nearly stabilized at around 64Mha and restoration of degraded lands assumes priority in planning and implementation. Between 1980 and 1990, forests were depleted at the rate of about 0.34mha annually while, afforestation efforts covered about one mha of area annually during the same period [35]. Overgrazing and deforestation have caused degradation in eight Indian states which now have >20% wasteland as reported by Bhattacharyya et al. [27] based on wasteland atlas of India prepared by National Remote Sensing Agency (NRSA).

Shifting cultivation predominantly in the North Eastern states, comprising of eight states namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, is another problem for environment and of course for the soil. This shifting cultivation, known as 'jhum' is widely distributed upland slash and burn agriculture system. Efforts to address jhum remained challenging tasks, more so due to its shortening cycle and ecological threats but continued livelihood dependency for a large population of upland communities. Such cultivation practices are linked with the ecological, socio-economic and cultural life of the people and are closely connected to their rituals and festivals. The current practice of shifting cultivation in the region is an extrav-

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agant and unscientific form of land use. Its evil effects are devastating and far reaching in degrading the soil, environment and ecology of this region [34]. Such areas could be easily recognized as a barren patch in the middle of the green surroundings. Though the state and central governments are making all possible effort to let the people settle down and follow sustainable agriculture, yet much more is needed through strategic planning.

Land degradation

Land degradation may be either a change to land that makes it less useful for human beings [35] or it may be a decrease in the optimum functioning of soil in ecosystems" [36] or the loss of utility or potential utility through the reduction or damage to physical, social, cultural or economic features and/or reduction of ecosystem diversity [37]. Estimated total area under soil degradation in India is around 147 million hectares (Mha) of land, including 94Mha from water erosion, 16Mha from acidification, 14Mha from flooding, 9Mha from wind erosion, 6Mha from salinity, and 7Mha from a combination of factors [27]. According to Sehgal and Abrol [38], about 187.8Mha (57% approximately) out of 328.73Mha of land area has been degraded in one way or the other. It appears, therefore, that most of our land is either degraded or is undergoing degradation or is at the risk of getting degraded. This is extremely serious because India supports 18% of the world's human population and 15% of the world's livestock population but has only 2.4% of the world's land area. Despite its low proportional land area, India ranks second worldwide in farm output. Agriculture, forestry, and fisheries account for 17% of the gross domestic product and employs about 50% of the total workforce of the country. Causes of soil degradation are both natural and human-induced [27]. Human-induced soil degradation results from land clearing and deforestation, inappropriate agricultural practices, improper management of industrial effluents and wastes, over-grazing, careless management of forests, surface mining, urban sprawl, and commercial/industrial development. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning. Some underlying social causes of soil degradation in India are land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty, and population increase [27,37].

Land degradation is a cumulative term used to cover the type specific human induced processes that may impair the capacity of the soil to function. Soil degradation affects human nutrition and health through its adverse impacts on quantity and quality of food production. Soil nutrient loss is a major concern. Overgrazing can result in both sparse pasture cover and loss of the range species that are preferred by livestock and thus cause degradation. During the last few decades, emerging incidences of contamination (include arsenic, selenium, fluoride and radionuclides) are of serious concern to ecosystem and human health [27].

Desertification

The term desertification refers to specific degradation of land in arid, semi-arid and sub-humid areas. In fact, land degradation occurs everywhere but is known as desertification when it occurs in dry land ecosystem, where mean annual precipitation is less than two thirds of potential evapotranspiration. Desertification is a type of land degradation in which a relatively dry area of land becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. Desertification process leads to desert formation [39]. This may result either due to a natural phenomenon linked to climate change or due to abusive land use. World day to combat desertification and drought is observed every year on 17th of June to increase public awareness on such issue.

India, with about 32% of its land under degradation and 25% undergoing desertification, has a huge task cut out to ensure sustainable land management as well as food, water and livelihood security by adopting both preventive and curative strategies for moving towards land degradation neutrality in a realistic timeframe [40]. Latest Atlas of the Space Applications Centre (SAC, ISRO) published in 2016 revealed that 96.4Mha (29.32%) is undergoing land degradation while 23.32% area is under desertification (ICAR-Central Arid Zone Research Institute, Jodhpur). The Indian Desert is unique among deserts of the world, because it is heavily populated including humans and livestock [41]. The Rajasthan desert contains a mixture of peninsular, extra-peninsular, and Indo-Gangetic geographical features. Historically, it was the seat of the Mohenjodaro-Harappa-Kalibanga civilizatibns [39].

Desertification is the extreme degradation of productive land in arid and semi-arid areas. This can create poor quality of vegetation, and cause spreading of desert to areas that were not desert before. Earlier the problem was confined to only the arid and semi-arid regions, but now it has taken a wider expansion in different climatic zones of the country. Poor agriculture practices, mismanagement of surface and ground water, inappropriate irrigation practices, absence of aridity control program or desert control program, and the impact of climate change do aggravate the desertification process in India. Many of the present schemes and programmes of Ministry of Rural Development, Department of Land Resources, Ministry of Environment, Forest and Climate Change, Ministry of Agriculture, Ministry of Water Resources, Ministry of Tribal Affairs, Ministry of Panchayati Raj, Department of Science and Technology, Department of Space have significant bearing for addressing the DLDD challenges. Though India does not have a specific policy or legislative framework for combating desertification as such, the concern for arresting and reversing land degradation and desertification gets reflected in many of our national policies (for e.g., National Water Policy 2012; National Forest Policy 1988; National Agricultural Policy 2000; Forest (Conservation) Act 1980; Environment (Protection) Act 1986; National Environmental Policy 2006; National Policy for Farmers 2007; National Rainfed Area Authority (NRAA)- 2007) which have enabling provisions for addressing these problems. It is also implicit in the

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goals of sustainable forest management (SFM), sustainable agriculture, sustainable land management (SLM) and the overarching goal of sustainable development which the country has been pursuing. The subject has in fact been engaging the attention of our planners and policy makers since the inception of planning. The first five years plan (1951-1956) had 'land rehabilitation' as one of the thrust areas. In the subsequent plans too, high priority for development has been consistently given to sustainable management of the type specific dryland soils in India.

Desertification often starts as patchy destruction of productive land. Increased dust particles in atmosphere lead to desertification and drought in margins of the zones that are not humid. Even the humid zones are in danger of getting progressively drier if droughts continue to occur over a series of years. Indications are clear that the temporary phenomena of meteorological drought in India are tending to become permanent one. This trend is not restricted to the fringes of existing deserts only. The ICAR-CAZRI [42] is devoted to;

a. Undertaking basic and applied research on sustainable farming systems in the arid ecosystem.

b. Act as repository of information on the state of natural resources and desertification processes.

c. Developing livestock-based farming systems and range management practices for the chronically drought-affected areas.

d. Generating and transferring location-specific technologies.

Erosion

It is the detachment, transportation and deposition of sediments mostly by natural factors like water and wind, but human induced accelerated erosion is also of serious concern. The NE Region, Himanchal Pradesh, Jammu & Kashmir, Jharkhand and Uttarakhand are typical for such erosion in India. Narayana and Ram Babu [43] analyzed the existing data on soil loss and concluded, as a first approximation, that soil was being eroded at an annual average rate of 16.35tonnes per hectare. Gurmel et al. [44] estimated that the annual erosion rate ranges from less than 5tonnes/ha for dense forests, snow-clad cold deserts, and arid regions of western Rajasthan to more than 80tonnes/ha in the Shiwalik hills. The arid and semi-arid regions of the north-west cover 28 600 square kilometers, of which the sand dunes and sandy plains of western Rajasthan, Haryana, Punjab, and Gujarat account for 66% [45]. Severe wind erosion is observed mostly in the extreme western sectors of the country. It is reported that the removal and deposition of sand during a 100-day period from April to June ranges between 1449 and 5560tonnes/ha [44]. The earlier estimates show that area affected by wind erosion is 13.5mha (4.1% of the total geographical area).

The loss of topsoil accounts for 1.9% of the total area under soil degradation; terrain deformation for 1.2%; and shifting of sand dunes another 0.5% [38]. At the Central Soil & Water Conservation Research & Training Institute, Dehradun, Dhruva and Ram Babu [46] presented a method to arrive at a first estimate of soil erosion, sediment loads of rivers and sedimentation in reservoirs. In this analysis, existing annual soil loss data for 20 different land resource regions of the country sediment loads of some rivers, and rainfall erosivity for 36 river basins and 17 catchments of major reservoirs are utilized and statistical regression equations are developed for predicting sediment yield. Using these expressions and corresponding values of area, rainfall, rainfall erosivity and surface runoff, annual values of total sediment loads of streams, sediment deposition in reservoirs, and sediment lost permanently into the sea are estimated. According to this estimate, which is treated as a first approximation, soil erosion is taking place at the rate of 16.35ton/ha/annum which is more than the permissible value of 4.5-11.2ton/ha. About 29% of the total eroded soil is lost permanently to the sea. Ten percent of it is deposited in reservoirs. The remaining 61% is dislocated from one place to the other [46]. Anthropogenic interferences are significant in accelerating the type specific erosion processes [47].

Acidification

This is more common in highlands like NE region. The acidification occurs when the basic cations (like calcium and magnesium) leach down from the soil, leaving the acidic cations on the soil surface (hydrogen, aluminium, iron and manganese). The pH decreases and soil becomes more acidic. In India, acid soils occur in Assam, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland, Sikkim, Manipur, Tripura, West Bengal, Jharkhand, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, M.P., Maharashtra, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. However, Punjab, Haryana, Rajasthan and Gujarat are the only states in India where acid soils do not occur naturally. Out of 142Mha of arable land, around 48-49Mha is occupied by acid soils, of which 25Mha show pH below 5.5 and 23Mha have pH between 5.6 to 6.5 [48,49]. Maji et al. [48] reported that out of the country's total geographic area, strongly acid and moderately acid soils covered 6.24 (1.9%) and 24.41 (7.4%) Mha. In the north-eastern region of India, approximately 95% soils are acidic, and nearly 65% soils are suffering from strong acidity with pH less than 5.5 [48]. The soils of Mizoram are particularly the product of slow diagenetic changes of acidic parent material giving the soils inherent acidic character [50]. Continuous efforts by man for developing permanently submerged areas into cultivable land, or for improving drainage in submerged or saline lands, regular use of nitrogen fertilizers like ammonium sulphate which cause acidity in the soils are responsible for decrease of soil pH. In urban areas, industrial wastes containing sulphur or sulphur dioxide also contribute much in the development of acid soils.

Salinization and sodification

The build-up of soluble salt on the soil surface or sub-surface often under faulty irrigation is serious soil problems particularly in arid and semi-arid environments. This is an alarming problem in the western states of Rajasthan and Gujarat as well as in adjoining areas. In most cases, salinization is associated with sodium-

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ization or sodification or alkalinisation due to excess of exchangeable sodium on exchange surface. According to current estimates, about 6.74Mha of total land areas qualify for salt affected soils with 1.71Mha under saline, 3.78 Mha under sodic and 1.24Mha under coastal saline soils in India [51,52].

Murthy et al. [53] presented the details of occurrence of the salt affected soils of India. Salinity and alkalinity occur extensively in the northern alluvial soils, flanked by the Rann of Kutch and the Rajasthan desert in the west and subhumid to humid, deltatic, marshy and swampy lands of the Sunderbans subject to tidal action in the east. The salt affected soils also occur in the major deltas in the east along the coastline, in major river basins and local depressions in the semi-arid Deccan plateau and its periphery, extending to the states of Maharastra, Andhra Pradesh, Karnataka and Tamilnadu. Narrow coastal strips in Kerala and West Bengal have acid sulphate soils. The introduction of irrigation is likely to result in secondary salinization. The operating mechanisms of salt release, mobilization and accumulation under varying situations are presented by Bhargava et al. [54]. Salinity is usually the first stage of alkalinity. The problem of salinity is related to the presence of a permanent water table developed at some depth below the soil surface and depends largely on soil-crop management [55]. A rise in water table in the south-western part of Haryana has created a serious problem of soil salinization [56].

Sodic or alkali soils are characterized by a disproportionately high concentration of sodium (greater than 15% exchangeable sodium) in their cation exchange complex showing high pH, greater than 8.5. The soils occur normally within arid to semiarid regions and are exhibiting poor physical, chemical and biological properties, which impede water infiltration, water availability, root penetration and ultimately plant growth and development. The maintenance of high pH in alkaline soils indicates that the supply of binding divalent metals is limited. It describes the interrelationships between salinity, irrigation, drainage, and crops. The evolution of such soils is related with micro-relief, brackish ground water and high evapo-transpiration [57], wherein anthropogenic interaction seems to have ample opportunities.

Mining

Mining is primarily a manmade problem with soils. Surface mining may deform the landscape. Besides, mining of sand from rivers and stones from the surrounding hills are common phenomena nowadays. Mineral rich states like Jharkkhand, Chhattishgarh, Odissa, Karnataka, Andhra Pradesh and Tamil Nadu have larger area where the land is severely damaged, and soils are badly affected with the presence of mined materials like metals, minerals and even radioactive materials. Opencast mining is of particular focus because it disturbs the physical, chemical, and biological features of the soil and alters the socioeconomic features of a region. Negative effects of mining are shortage of water due to lowering of water table, soil contamination, loss of soil biodiversity with flora and fauna, increase in air and water pollution and acid mine drainage. Besides, overburden removal from mining sites results in considerable loss of top soils and vegetation [58]. Open-pit mines produce 8 to 10 times as much waste as underground mines [59].

Coal is one of the most commonly available fossil fuels which meets the requirements of major part of the energy for human consumption globally. India is the third largest coal producer in the world after China and USA. Coal mining and related activities provide huge energy resource; however, such human interferences adversely affect the soil as well as environment causing degradation and deforestation. The first published record of coal mining in India dates back to the year 1774 in coal mines in Bengal. The major coal fields include Jharia, Raniganj, Nagpur, Singareni, Talcher, Neyveli, and Chandrapur. Out of these, Jharia coal field (JCF) is the major storehouse of coking coal. Jharia has a long history of mining, which started around the end of the 19th century [60]. Haphazard mining by human beings over nearly a century has led to multiple deterioration in environmental and soil qualities besides degradation in landform, land use/land cover, vegetation distribution. Jharia is also known for widespread development of surface and subsurface fires due to unsustainable mining practices. These fires are burning over nearly a century and are a major cause of soil and air pollution, loss of vegetation as well as subsidence [61]. Some parameters such as total dissolved solids (TDS), Fe, nitrite, hardness, conductivity, heavy metals in the surface and groundwater exceed the defined quality standards [62,63].

Figure 5: Coal burning, soil and vegetation in Jharkhand.

Soil is polluted due to strip mining as it involves removal of top soil, wind erosion from dumps, coal heaps, tailing ponds, dust generated due to heavy machinery used for extracting coal, burning of coal, loading and unloading of coal as this dust settles on nearby areas. Soil has poor texture, low organic matter, and exhibits change in nutrient content due to heavy metal toxicity, change in pH and electrical conductivity. Also, the soil above the fire areas (Figure 5) is devoid of moisture and is baked making it biologically sterile [64]. The soil friendly organisms (bacteria, nematodes, earthworms, etc.) die under such harsh conditions, thus limiting the ability of the soil to support vegetation. The existing vegetation also dries up and ultimately dies due to the lack of water and other nutrients. The soil quality is affected by removal of top soil and low accumulation of humus resulting in lower organic content. The soils have high bulk density, large grain size, acidic pH and high electrical conductivity, which cumulatively make the soil less potent for plant growth [61]. Jharia coalfield is facing signif-

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icant subsidence due to underground mining [65,66]. However, Sanjay et al. [67] attempted to restore soil development in 2-21 years old coalmine in Raniganj with trees, although such issue needs creative planning approach in view of the fact that mining is by and large a human necessity but not at the cost of soil. Tekedil and Srivastava [68] highlighted impacts due to mining based on a case study in Kerala.

Urbanization and industrialization

Rural inhabitants prefer to settle in the city for reasons of better employment opportunities and social as well as cultural mobility. Old cities in India have grown in a haphazard and unplanned manner and often remain impacted due to industrialization. Cities are over-populated and over-crowded as a result of the increase in population over the decades and partly as a result of migration. Ill-effects of fast-growing urbanization in India are documented [69]. Urbanization and industrialization are purely because of human interferences and cause abrupt changes in localized climate, polluted environment and land degradation.

Urbanization leads to irreversible shifting of agriculturally viable lands for non-farming uses. In fact, urbanization as well as industrialization is the two land uses, which bring the maximum change on the face of earth visibly. Changes appeared include non-farming through soil sealing irreversibly, wherein soil in the landscape is physically, chemically and even biologically distorted and it is often covered by stones or bricks with concretion or roads, buildings, playground or picnic spots or ponds and streams. Thus, land utilization types are virtually changed from agriculture to urban settlement and infrastructure. Importantly, the urban environment brings changes in the local climate invariably, wherein temperature is always warmer as compared to its surrounding areas and the city or town is like "heat-island".

Urbanization is directly related to shrinkage of agricultural lands for non-farming purposes and thus directly responsible for localized climate warming besides promoting the soil pollution as well as erosion. Such serious issue deserves intervention of policies both at state and central government levels through planning. Urbanization would immensely accelerate the process of soil sealing. Soils are commonly disturbed, mixed and compacted resulting in changes in physical and chemical properties of soils. Besides, urbanization subsequently promotes the risk of floods and drought, endangers the soil biodiversity, influences the amount, chemical form and spatial distribution of carbon stocks leading to environmental change. In such unplanned package of alteration, soil gets often covered with impervious surfaces too. Soil sealing is the principal cause due to urbanization [70].

Topography, vegetation, climate, water table, and even the anthropogenic activities all are affected by urban growth through diverse mechanisms. The expansion of urban area of Gwalior in central India has been quantified by deriving data for four decades (1972-2013) from the Landsat images [71]. The urban built-up area has increased by 08.48 sq. km during the first eighteen years (1972-1990) which has increased to 16.28 sq. km during the next sixteen years (1990-2006). The built-up area has gone up to 23.19sq. km in the next seven years (2006-2013). Overall during the last 40 years, the growth of the urban built-up is nearly three times of the built-up areas in 1972. The average decadal growth rate of population is 27.28 percent while that of built-up land is 36.29 percent [71]. Such expansion in urbanization is directly proportional to shrinkage of land area following the irreversible change in productive soils too [72-74]. As Sanyal [75] remarked, the abuses and misuses of soil such as the irreversible destruction of good quality top soil in course of brick making and other activities like solid waste disposal (Figure 6) particularly in urban and industrial areas need to be highlighted to the public and policy makers in order that such practices are stopped or regulated and/or reversed for saving the precious natural resource. The Yamuna in Delhi has been facing a challenge due to urban solid waste disposal.

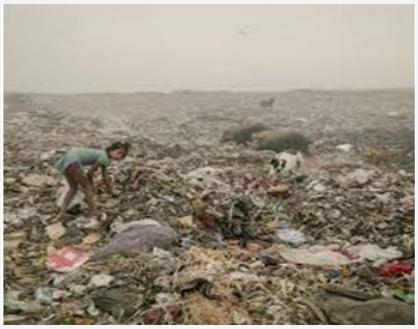

Figure 6: Solid waste polluting soils around Delhi.

Conclusion

The values of a soil are well established since time immemorial. However, since last century and so, the land-man ratio declined almost exponentially primarily due to rapid increase in human population (population density), diversion of agricultural land irreversibly for urbanization and other infrastructure purposes including type specific land degradation and desertification. The land resources in India are virtually scarce and threatened with multiple types of challenges. The ill-impacts on soils under such risk prone lands are infinite. Even though, in order to meet the people's needs, the soils have been extensively and intensively utilized under imbalanced management practices for years together. This resulted in complex types of threats, pollution, vulnerability, toxicity, loss of biodiversity, decline in organic matter and unstable soil sustainability and resilience.

However, such deteriorating trends of soil health have now been gradually realized and understood by the farming communities as well as policy makers. They are being sensitized by the government agencies and research institutes and universities through their innovative research and development approaches. Indian soils are, by and large, correctable in general for improvement in order to attain the level of potential productivity of the soils. So, the humans would look for precision soil evaluation and

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turn the soil healthy, productive and sustainable for present and brighter future. It is in the interest of humans to keep the soils sustained as soil is the ultimate essence of our existence. Soil is still a strange full of wisdom that needs to be captured using classical laws of sciences.

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