



Spatial Variability of the Available Soil Nutrients in the Shekhawati Part of the Thar Desert, India

¹Mukesh Kumar Meena & ²Naveen Kumar

¹Assistant Professor, Dept. of Botany, Govt. College, Ratangarh, Rajasthan, India

²Assistant Professor, Dept. of Botany, RN Ruia Govt. College, Ramgarh, Shekhawati, Sikar, Rajasthan, India

ABSTRACT: Spatial variability occurs when a quantity that is measured at different spatial locations exhibits values that differ across the locations. Spatial variability can be assessed using spatial descriptive statistics such as the range.

Let us suppose that the $Rev' z(x)$ is perfectly known at any point x within the field under study. Then the uncertainty about $z(x)$ is reduced to zero, whereas its spatial variability still exists. Uncertainty is closely related to the amount of spatial variability, but it is also strongly dependent upon sampling.^[1]

Geostatistical analyses have been strictly performed to study the spatial variability of pesticide sorption^{[2][3][4]} and degradation^[5] in the field. Webster and Oliver^[6] provided a description of geostatistical techniques. Describing uncertainty using geostatistics is not an activity exempt from uncertainty itself as variogram uncertainty may be large^[7] and spatial interpolation may be undertaken using different techniques.^[8]

KEYWORDS: spatial variability, Thar, desert, soil nutrients, Shekhawati, sampling, interpolation

I.INTRODUCTION

In general, soil is composed of four elements:

1. Inorganic or mineral fractions derived from the parent material
2. Organic matter (decayed and decomposed plants and animals)
3. Air
4. Water^[1,2]

Soil is formed under specific natural conditions and each of the elements of the natural environment contributes to this complex process of soil formation known as “pedogenesis”.

Soil Profile

The soil profile is a vertical cross-section of the soil, made of layers parallel to the surface. Each layer of soil has a different texture and is known as the horizon.

- Horizon A (Topsoil) – It is the topmost layer where the organic materials have got incorporated with the mineral matter, nutrients and water – elements necessary for the growth of plants.
- Horizon B (Subsoil) – This zone has a greater content of minerals and humus is present in smaller quantities. It represents a transition between Horizon A and Horizon C and contains matter derived from below as well as above. ^[3,4]
- Horizon C (weathered and decomposed rock) – This zone is composed of the loose parent/rock material. This layer is the first stage in the soil formation process and eventually forms the above two layers.

Underneath these three horizons is the rock which is known as the parent rock or the bedrock.

Different Types of Soil in India

In the ancient period, soils were mainly classified into two – Urvara (fertile) and Usara (sterile).

The first scientific classification of soil was done by Vasily Dokuchaev. [47,48] In India, the Indian Council of Agricultural Research (ICAR) has classified soils into 8 categories. They are:

1. Alluvial Soil
2. Black Cotton Soil
3. Red & Yellow Soil
4. Laterite Soil
5. Mountainous or Forest Soil
6. Arid or Desert Soil
7. Saline and Alkaline Soil[5,6]
8. Peaty and Marshy Soil

As mentioned before, there are eight types of soils categorized by ICAR but some Indian Soils like – Karewa soil, Sub-Montane Soil, Snowfield, Grey/Brown Soil are all sub-types of main Indian Soil.

Types of Soil in India – Alluvial Soil

- Alluvial soils are widespread in the northern plains and river valleys.
- It covers about 40% of the total land area of the country.
- These soils are mainly derived from the debris brought down from the Himalayas.
- In the Peninsular region, they are found in deltas of the east coast and in the river valleys.
- The colour of the alluvial soil varies from light grey to ash grey.
- The alluvial soil varies in nature from sandy loam to clay.
- They are rich in potash but poor in phosphorus.
- Two different types of alluvial soils have developed in the Upper and Middle Ganga plains – Khadar and Bhangar.[7,8]
 - Khadar is the new alluvium and occupies the flood plains of the rivers. Khadar is enriched with fresh silt deposits every year.
 - Bhangar is the old alluvium, deposited away from the flood plains.
- Both Khadar and Bhangar soils contain concretion (kankars) of impure calcium carbonate.
- These soils are more loamy and clayey in the lower and middle Ganga plains and the Brahmaputra valley.
- Alluvial soils are intensely cultivated – wheat, maize, sugarcane, pulses, oilseed, etc. are mainly cultivated.

Types of Soil in India – Red & Yellow Soil



- Also known as the “omnibus group”.
- It covers about 18.5 % of the total land area of the country.
- It is found in regions of low rainfall (eastern and southern parts of the Deccan Plateau). Along the piedmont zone of the Western Ghats, a long stretch of area is occupied by red loamy soil. This soil is also present in parts of Odisha and Chattisgarh and in the southern parts of the Middle Ganga Plain.
- The red colour is due to the presence of iron in crystalline and metamorphic rocks. The soil appears yellow when it is in hydrated form.[9,10]
- The fine-grained red and yellow soil is usually fertile while the coarse-grained soil is less fertile.

- This type of soil is generally deficient in nitrogen, phosphorus and humus.
- Wheat, cotton, oilseeds, millets, tobacco, and pulses are mainly cultivated in red and yellow soil. [45,46]

Types of Soil in India – Black or Regur Soil



- Black soil is also known as “Regur Soil” or the “Black Cotton Soil”.
- It covers about 15% of the total land area of the country.
- It covers most of the Deccan Plateau – parts of Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu. In the upper reaches of the Godavari and Krishna, and the north-western part of the Deccan Plateau, the black soil is very deep.
- The colour of these soils varies from deep black to grey.
- The black soils are generally clayey, deep and impermeable. They swell greatly and become sticky when wet in the rainy season. In the dry season, the moisture evaporates, the soil shrinks and develops wide cracks.
- Black soils are rich in iron, lime, aluminium, magnesium and also contain potassium. However, these soils are deficient in nitrogen, phosphorus and organic matter.
- Cotton, pulses, millets, castor, tobacco, sugarcane, citrus fruits, linseed, etc. are mainly cultivated in black soil.

Types of Soil in India – Desert Soil



- Also known as arid soil, it accounts for over 4.42 % of the total land area of the country.
- The colour ranges from red to brown.
- Desert soils are sandy to gravelly in texture, have low moisture content and low water-retaining capacity.
- These soils are saline in nature and in certain regions, the salt content is so high that common salt is obtained by evaporating water. [11,12]
- These soils have normal phosphate content but are deficient in nitrogen.
- Due to increased calcium content in the lower horizons of the soil, there is the formation of ‘kankar’ layers. These kankar layers restrict the penetration of water and as such when water is made available through irrigation, the soil moisture is readily available for sustainable plant growth. [43,44]
- Desert soils are profoundly found in western Rajasthan and contain little humus and organic matter.

Types of Soil in India – Laterite Soil



- The name has been derived from the Latin word “later” which means brick.
- It accounts for about 3.7% of the total area of the country.
- These are typical soils of the monsoon climate which is characterised by seasonal rainfall. With rain, lime and silica are leached away, and soil rich in iron oxide and aluminium are left leading to the formation of laterite soil.
- Laterite soil is deficient in organic matter, nitrogen, phosphate and calcium, however, iron oxide and potash are in abundance.
- Although low in fertility, they respond well to manures and fertilisers.
- Laterite soils are found in Karnataka, Tamil Nadu, Kerala, Madhya Pradesh and hilly regions of Assam and Odisha.
- Red laterite soil in Kerala, Tamil Nadu and Andhra Pradesh are well suited for tree crop cultivation like cashew nuts.
- Laterite soil hardens rapidly and irreversibly on exposure to the air, a property that leads to its use as building bricks in southern India.

Types of Soil in India – Mountain Soil



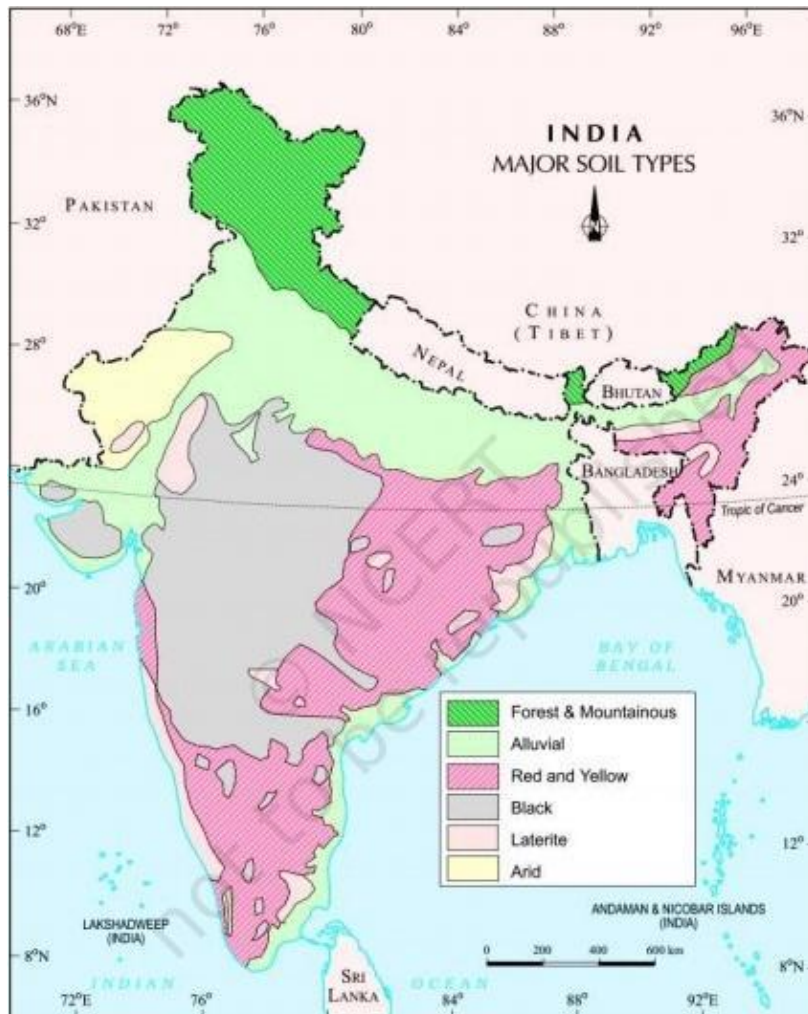
- This type of soil is found in forest regions where rainfall is sufficient.[41,42]
- The texture of the soil depends on the mountain environment where they are found.
- These soils are coarse-grained in the upper slopes and loamy and silty on valley sides.
- In the snowbound areas of the Himalayas, these soils undergo denudation and are acidic with low humus content. The soils found in the lower valleys are fertile.
- Also called forest soil.[13,14]

Types of Soil in India – Peaty and Marshy Soils



- These soils are found in regions of heavy rainfall and high humidity, and it supports the good growth of vegetation.
- Peaty soils are rich in humus and organic matter.
- These soils are generally heavy and black in colour. In many places, these soils are alkaline.
- These are found in southern Uttarakhand, the northern part of Bihar, and the coastal areas of West Bengal, Odisha and Tamil Nadu.

Types of Soil in India – Saline and Alkaline Soils



- These soils have high percentages of sodium, magnesium and potassium, and hence are infertile. The high salt content is mainly because of the dry climate and poor drainage.[39,40]
- The texture ranges from sandy to loamy.
- These soils are found in arid and semi-arid areas, and in waterlogged and swampy regions.
- These soils are deficient in calcium and nitrogen.[15,16]
- These soils are mostly found in western Gujarat, deltas of the eastern coast and in Sundarban areas of West Bengal. In the Rann of Kutch, the south-western monsoon brings salt particles and deposits there as a crust. Seawater near deltas also increases the salinity of the soil.
- These soils can be reclaimed by improving drainage, by applying gypsum or lime and by cultivating salt-resistant crops like berseem, dhaincha, etc.
- These are also called Reh, Usar, Kallar, Rakar, Thur, and Chopan. These are mainly found in Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, and Maharashtra. Sodium chloride and sodium sulphate are present in this soil. It is suitable for leguminous crops.

II.DISCUSSION

Types of Soil in India – Red and Black Soil

These are developed over the granite, gneiss, and quartzite of the Precambrian and Archean eras. This soil performs well if irrigated. Generally, this soil has very little productivity.[37,38]



Grey and Brown Soil

These soils are found in Rajasthan and Gujarat. It is formed by the weathering of granite, quartzite and gneiss. These loose, friable soils contain iron oxide (haematite and limonite).

Submontane Soil

These are formed by the deposition of eroded material from Shiwaliks and the lesser Himalayas. These are found in the Tarai region of the submontane stretching from Jammu and Kashmir to Assam. The soil supports a luxuriant growth of forest and is more prone to soil erosion.[17,18]

Snowfields

This soil was found under the snow and glaciers at the highest peak of the greater Himalayas, Karakoram, Ladakh, and Zaskar. This soil is immature and unsuitable for crops.

Karewa Soil

Karewa soils are the lacustrine deposits in the Kashmir Valley and the Bhadarwah Valley. Fine silt, clay, and boulder gravels are the composition of Karewa soil. They are characterized by fossils. These soils are mainly devoted to the cultivation of saffron, almonds, apple, walnut, etc.

Classification of Indian Soil as per USDA

The ICAR (Indian Council of Agricultural Research) has classified Indian soil on the basis of its nature and characteristics as per the United States Department of Agriculture (USDA) Soil Taxonomy.

S.No	Order	Percentage
1.	Inceptisols	39.74
2.	Entisols	28.08
3.	Alfisols	13.55
4.	Vertisols	8.52
5.	Aridisols	4.28
6.	Ultisols	2.51
7.	Mollisols	0.40
8.	Others	2.92
		Total – 100

Soil Erosion

Soil erosion refers to the removal of topsoil. The formation of soil and the erosional processes occur simultaneously and generally, there is a balance between the two processes. However, sometimes the balance gets disturbed leading to faster removal of soil than its formation which results in soil erosion.

- In areas where the rainfall is heavy, water is the main agent of soil erosion, while in arid and semi-arid regions wind is responsible for soil erosion.[35,36]
- Water erosion takes place mainly in the form of sheet and gully erosion.



- When the topsoil is removed it is known as sheet erosion and takes place on level lands after a heavy shower.
- When the run-off makes gullies it is known as gully erosion and is common on steep slopes.
- Gullies deepen with rainfall, cut the agricultural lands into small fragments and make them unfit for cultivation.
- A region with a large number of deep gullies or ravines is called a “badland topography”. A typical example of gully erosion is provided in the Chambal Valley (Madhya Pradesh). They are also found in Tamil Nadu and West Bengal.[19,20]
- Eroded materials due to soil erosion are carried down to rivers and thereby decreasing their water-carrying capacity which leads to frequent floods and damage to agricultural lands.
- The tidal waters of the Arabian Sea and the Bay of Bengal cause considerable damage to the soils along the coastal areas. Severe erosion of beaches along the Kerala, Tamil Nadu, Odisha, West Bengal and Gujarat coasts are examples of sea-wave erosion.
- Deforestation is one of the major causes of soil erosion and its effect is more pronounced in the hilly parts of the country.
- Intensive agricultural practices that rely heavily on water and chemical fertilisers have caused waterlogging and salinity in many parts of the country, reducing the fertility of the soil in the long run. This problem is common in almost all the areas of the river valley projects, which were the first beneficiaries of the Green Revolution. According to estimates, about half of the total land of India is under some degree of degradation.

Every year India loses millions of tonnes of soil and its nutrients to the agents of its degradation, which adversely affects our country's productivity. [33,34]

Soil Conservation

Soil conservation is a methodology to maintain soil fertility, prevent soil erosion and improve the degraded condition of the soil. Soil conservation practices are those farming operations and management strategies conducted with the goal to control soil erosion by preventing or limiting soil particle detachment and its transport in air or water.[21,22]

- Contour bunding, contour terracing, controlled grazing, regulated forestry, cover cropping, mixed farming and crop rotation are some of the remedial measures adopted to reduce soil erosion.
- Afforestation (planting of trees) helps in reducing soil erosion and it is equally important to check the indiscriminate felling of trees.
- The problem of soil erosion is closely associated with floods. Floods generally occur during the rainy season. Efforts, therefore, need to be made for the storage of floodwater or the diversion of additional rainwater. The interlinking of rivers like the Ganga-Kaveri Link Canal Project is of immense importance.
- Reclamation of gullies and ravines is also necessary to overcome the problem of soil erosion. Several such schemes involving plugging of gully mouths, construction of bunds across the gullies, levelling the gullies, and planting cover vegetation are under implementation in the Chambal ravines of Madhya Pradesh.
- In northeast India and the Western and Eastern Ghats, shifting cultivation (slash and burn) is one of the main causes of soil erosion. Such farmers should be motivated to adopt terraced farming. A scheme to control shifting cultivation has been launched in the seven states of northeast India. This is a beneficiary-oriented programme that aims at the rehabilitation of the families involved in shifting cultivation (Jhumming). This agricultural practice should be replaced by sedentary farming.

III.RESULTS

In Shekhawati region of Rajasthan is found maximum desert soil. A desert is a barren area of landscape where little precipitation occurs and, consequently, living conditions are hostile for plant and animal life. The lack of vegetation exposes the unprotected surface of the ground to denudation. About one-third of the land surface of the Earth is arid or semi-arid. This includes much of the polar regions, where little precipitation occurs, and which are sometimes called polar deserts or "cold deserts". Deserts can be classified by the amount of precipitation that falls, by the temperature that prevails, by the causes of desertification or by their geographical location.^[1]



Deserts are formed by weathering processes as large variations in temperature between day and night put strains on the rocks, which consequently break in pieces. Although rain seldom occurs in deserts, there are occasional downpours that can result in flash floods. Rain falling on hot rocks can cause them to shatter, and the resulting fragments and rubble strewn over the desert floor are further eroded by the wind. This picks up particles of sand and dust, which can remain airborne for extended periods – sometimes causing the formation of sand storms or dust storms. Wind-blown sand grains striking any solid object in their path can abrade the surface. Rocks are smoothed down, and the wind sorts sand into uniform deposits. The grains end up as level sheets of sand or are piled high in billowing sand dunes.[31,32] Other deserts are flat, stony plains where all the fine material has been blown away and the surface consists of a mosaic of smooth stones, often forming desert pavements, and little further erosion takes place. Other desert features include rock outcrops, exposed bedrock and clays once deposited by flowing water. Temporary lakes may form and salt pans may be left when waters evaporate. There may be underground sources of water, in the form of springs and seepages from aquifers. Where these are found, oases can occur.[23,24]

Plants and animals living in the desert need special adaptations to survive in the harsh environment. Plants tend to be tough and wiry with small or no leaves, water-resistant cuticles, and often spines to deter herbivory. Some annual plants germinate, bloom and die in the course of a few weeks after rainfall, while other long-lived plants survive for years and have deep root systems able to tap underground moisture. Animals need to keep cool and find enough food and water to survive.[29,30] Many are nocturnal, and stay in the shade or underground during the heat of the day. They tend to be efficient at conserving water, extracting most of their needs from their food and concentrating their urine. Some animals remain in a state of dormancy for long periods, ready to become active again during the rare rainfall. They then reproduce rapidly while conditions are favorable before returning to dormancy.

People have struggled to live in deserts and the surrounding semi-arid lands for millennia. Nomads have moved their flocks and herds to wherever grazing is available, and oases have provided opportunities for a more settled way of life. The cultivation of semi-arid regions encourages erosion of soil and is one of the causes of increased desertification. Desert farming is possible with the aid of irrigation, and the Imperial Valley in California provides an example of how previously barren land can be made productive by the import of water from an outside source. Many trade routes have been forged across deserts, especially across the Sahara, and traditionally were used by caravans of camels carrying salt, gold, ivory and other goods. Large numbers of slaves were also taken northwards across the Sahara. Some mineral extraction also takes place in deserts, and the uninterrupted sunlight gives potential for the capture of large quantities of solar energy.

The Thar Desert, also known as the Great Indian Desert, is an arid region in the north-western part of the Indian subcontinent that covers an area of 200,000 km² (77,000 sq mi) in India and Pakistan. It is the world's 20th-largest desert, and the world's 9th-largest hot subtropical desert.

About 85% of the Thar Desert is in India, and about 15% is in Pakistan.^[3] The Thar Desert is about 4.56% of the total geographical area of India. More than 60% of the desert lies in the Indian state of Rajasthan; the portion in India also extends into Gujarat, Punjab, and Haryana. The portion in Pakistan extends into the provinces of Sindh^[4] and Punjab (the portion in the latter province is referred to as the Cholistan Desert). The Indo-Gangetic Plain lies to the north, west and northeast of the Thar desert, the Rann of Kutch lies to its south, and the Aravali Range borders the desert to the east.[25,26]

Shekhawati is a semi-arid historical region located in the northeast part of Rajasthan, India. The region was ruled by Shekhawat Rajputs. Shekhawati is located in North Rajasthan, comprising the districts of Jhunjhunu, parts of Sikar that lies to the west of the Aravalis and Churu. It is bounded on the northwest by the Jangladesh region, on the northeast by Haryana, on the east by Mewat, on the southeast by Dhundhar, on the south by Ajmer, and on the southwest by the Marwar region. Its area is 13784 square kilometers.^[1]



Shekhawati region of Rajasthan

In the 17th to 19th centuries, Marwari merchants constructed grand havelis in the Shekhawati region. Steeped with wealth and affluence, the merchants attempted to outdo others by building more grand edifices – homes, temples, and step wells which both inside and outside were richly decorated with painted murals.^[2]

The soil here is sandy desert soil as explained above.

IV.CONCLUSIONS

Shekhawati is in the Thar Desert of Rajasthan and has special importance in the history of India. It also covers part of the Bagar tract along the Haryana-Rajasthan border.[27,28]

The climate of the desert region is harsh and extreme. The temperature ranges from below 0 °C (32 °F) in winter to more than 50 °C (122 °F) in summer. The summer brings hot waves of air called loo. Annual rainfall is at around 450 to 600 mm. The groundwater is as deep as 200 feet (60 m), and in some places, the groundwater is hard and salty. The people in the region depend on rainwater harvesting. The harvested rainwater from the monsoon season (during July and August) is stored in pucca tanks and used throughout the year for drinking purposes.^[13]

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