Chronicle of Bioresource Management 2021, 5(4):121-127

Chronicle of Bioresource Management
An International E-magazine

December 2021 | Popular Article

Corresponding Author
M. Chandrakala
e-mail: chandra.ssac@gmail.com

Citation: Chandrakala et al., 2021. Indian Soils: Characteristics, Distribution, Potentials and Constraints. Chronicle of Bioresource Management 5(4), 121-127.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Keywords:
Characteristics, constraints, potentials, soils, threats

Article History
Article ID: CBM84
Received on 01st October 2021
Received in revised form on 20th October 2021
Accepted in final form on 02nd November 2021

Indian Soils: Characteristics, Distribution, Potentials and Constraints

M. Chandrakala[1*], K. Lakhsman[2] and Sunil P. Maske[1]

Abstract

In India due to diversity in soil forming factors and processes, various soils are found except Andisols, Spodosols and Oxisols. Though there are few Spodosols yet they are not true Spodosols. There are eight kind of soils occurring in India *viz.*, alluvial soils (75 mha), black soils/Regur (72 m ha), red soils, laterite and lateritic soils (red and lateritic soils together occupied by 70 m ha), saline and alkali soils (10 m ha), desert soils (29 m ha), forest and hill soils (75 m ha), peaty and marshy soils. Alluvial and black soils are fertile whereas laterite, desert and alkaline soils are less fertile. There are nine key threats identified to soil include soil erosion, decline in soil organic matter (SOM), soil contamination, soil sealing, soil compaction, decline in soil biodiversity, soil salinization, landslides and desertification and also land-use change to be addressed to conserve agricultural crop lands.

1. Introduction

The nature and properties of Indian soils vary greatly depending upon the variations in soil forming factors and processes. India represents all the major soil groups of the world except Andisols, Spodosols and Oxisols (Sehgal, 1996). When the Soil survey of India was established in 1956, they studied soils of India and their characteristics. Later The National Bureau of Soil Survey and the Land Use Planning (1976), an institute under the control of Indian Council of Agriculture Research did a lot of studies on Indian soil and have developed soil map of India on 1:250,000 and 1:1 million scale, presently it is mapping soils of India on 1:10000 scale (Chandrakala et al., 2017 and Chandrakala et al., 2019). Physiography of India is classified into three broad groups which are i) Triangular plateau of the peninsula: Alfisols, Inceptisols, Vertisols and Entisols are predominant, ii) Mountain region of the Himalayas: Alfisols and Inceptisols are predominant and iii) Indo-Gangetic plain of Punjab and Bengal: Entisols, Inceptisols and Alfisols are predominant (Table 1) (ISSS, 2009). These soils were classified as per the US soil taxonomy (Figure 1). The genetic name with respective US taxonomy classes are given in table 2. There are nine key threats to soil were identified which are soil erosion, decline

Author's Address
[1]National Bureau of Soil Survey and Land Use Planning, Regional Centre, Hebbal, Bangalore, Karnataka (560 024), India
[2]Assistant Professor, Agriculture College, Bapatla, Acharya N.G. Ranga Agricultural University, Guntur district, A.P. (522 101), India

Table 1: Distribution of soils of India

Order	Area (Mha)	%
Alfisols	79.7	24.25
Entisols	80.1	24.37
Inceptisols	95.8	29.13
Vertisols	26.3	8.02
Aridisols	14.6	4.47
Mollisols	8.0	2.43
Ultisols	0.8	0.26
Oxisols	0.1	0.03
Histosols	-	-
Non classified (uncultivable land)	23.1	7.04
Total	328.5	100

Table 2: The soils of India with genetic names and their US soil taxonomy classes

Genetic names of Indian soils	US soil taxonomy
Alluvial soils	Inceptisols, Entisols, Alfisols, Aridisols
Black soils	Vertisols, Inceptisols, Entisols
Red soils	Alfisols, Inceptisols, Entisols
Laterite and lateritic soils	Oxisols, Ultisols, Inceptisols
Saline and alkali soils	Aridisols, Inceptisols, Alfisols, Entisols, Vertisols
Desert soils	Aridisols, Entisols
Forest and hill soils	Inceptisols, Alfisols, Mollisols, Ultisols, Entisols
Peaty and marshy soils	Histosols, Inceptisols, Entisols

in soil organic matter (SOM), soil contamination, soil sealing, soil compaction, decline in soil biodiversity, soil salinization, landslides and desertification and also land-use change imparts some of the other threats identified on the soil. Soil erosion removes important topsoil and, with it, nutrients, C and porosity. A reduction in soil organic matter mainly affects soil biological, microbiological and physical properties as it is linked with soil structure. Soil contamination affects soil chemical properties, affecting nutrient availability and degrading microbial properties, soil compaction deteriorates soil pore network. Soil

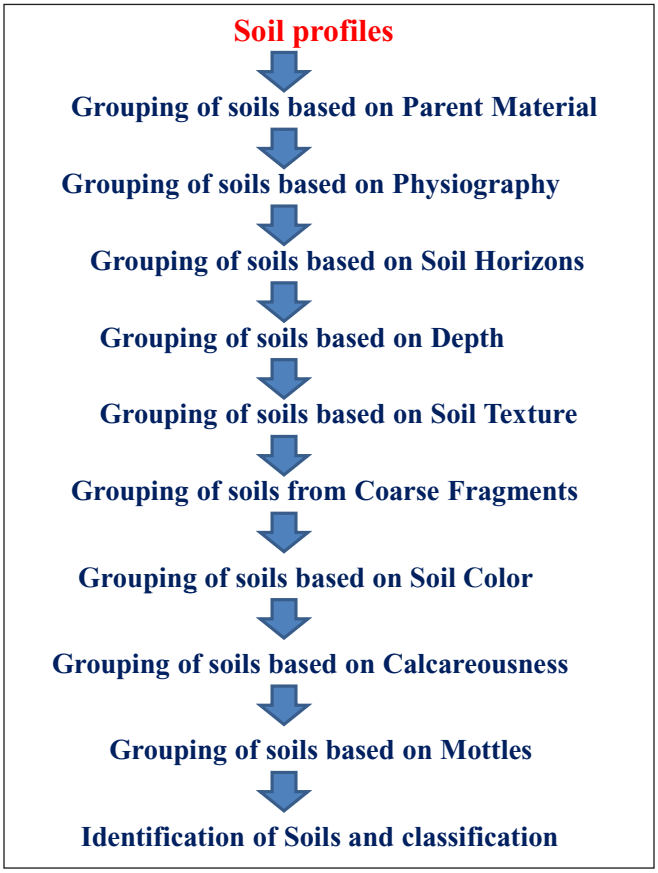


Figure 1: Flow chart showing the identification and classification of soils

sealing removes the link between the soil and most of the 'spheres', significantly affecting hydrological and microbial functions. Soil salinization restricts the land for potential agricultural crop production. Landslides affect the topography of land there by controls farming and household activities as it is directly linked to soil erosion. Desertification leads to degradation of land and land use. All these threats to soil leads to conversion of agricultural crop land to non agricultural purpose such as, grazing, mining, urbanization, industrialization etc.

2. Soils of India: Characteristics, Distribution, Potentials and Constraints

2.1. Alluvial soil

• Alluvial soils are formed mainly due to silt deposited by Indo-Gangetic-Brahmaputra rivers (Figure 2).

• Rocks of the Himalayas form the parent material. They are the largest soil group covering about 75 mha. They support more than 40% of the India's population. Humus, lime and organic matters are present. Highly fertile.

• New alluvium is termed as Khadar and old alluvium is termed as Bhangar.

• Distributed in northern, north-western and north-eastern parts of India including Punjab, Haryna, Uttar Pradesh, Delhi, Madhya Pradesh, Assam, Bihar, West Bengal, coastal regions of Orissa, Gujarath, Tamil nadu, Kerala etc.

• Pebbly and gravelly soils are rare. Kankar (calcareous concretions) beds are present in some regions along the river terraces.

• The soil is porous because of its loamy nature. Porosity and texture provide good drainage and other conditions favorable for agriculture. These soils are constantly replenished by the recurrent floods.

• Nitrogen is generally low whereas potash, phosphoric acid and alkalies are adequate and iron oxide and lime vary within a wide range.

• Best suited for agriculture. They are best suited to irrigation and respond well to canal and well/tube-well irrigation. They yield splendid crops of rice, wheat, sugarcane, tobacco, cotton, jute, maize, ground nut, potato, berseem, sunflower, oilseeds, vegetables and fruits.

Figure 2: Alluvial soils of Rayachoty mandal, YSR Kadapa District, Andhra Pradesh

2.2. Black Soils

• The parent material for most of the black soil are the volcanic rocks and lava that were formed in the Deccan Plateau and Rajmahal traps (Figure 3).

• In Tamil Nadu, gneisses and schists form the parent material soils formed from which are moderately shallow

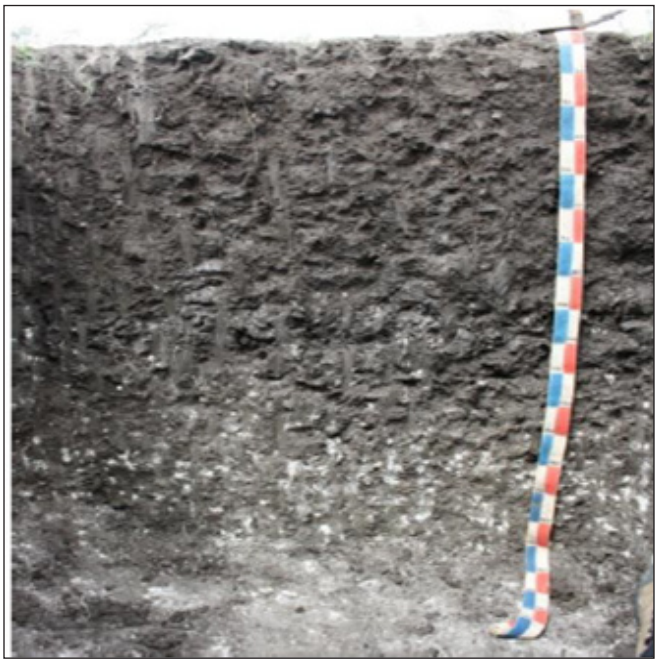


Figure 3: Black soils of Tamil Nadu (Kumar et al., 2017)

to moderately deep i.e. <100 cm cm while soils developed on basaltic parent rock under semiarid to subhumid climate are deep to very deep i.e.100 to >150cm.

• These are the region of high temperature and low rainfall. It is, therefore, a soil group typical to the dry and hot regions of the Peninsula.

• Black soil is also known as Regur in central India, Karail in lower Gangetic basin in UP, Bhal in Gujarat and Tal in Bihar.

• Black soil is also known as Black Cotton Soil as cotton is an important crop which is grown in this type of soil.

• This soil is rich in calcium carbonate, potash, lime and magnesium carbonate but has poor phosphorus content.

• Black soil is clayey and can hold a lot of moisture. It becomes sticky in the rainy season and develops cracks when dry (shrink-swell soils).

• Distributed in 72 m ha in central, western and southern states of India including Maharashtra, western part of Madhya Pradesh, Gujarat, parts of Andhra Pradesh, Karnataka and Tamil Nadu.

• A typical black soil is highly argillaceous containing clay 30-80 percent. In general, black soils of uplands are of low fertility while those in the valleys are very fertile.

• Soils developed on calcareous clay have $CaCO_3$ with pH >7.8 and up to 9.4. High exchange capacity (35-

55 cmol (p+) kg^{-1}). WHC is 150-250 mm/m due to clay of smectitic nature. They show clay eluviation and illuviation processes. BD is 1.5 to 1.8 Mg m^{-3}.

• The black color due to clay-humus complexes and titaniferour magnetite mineral and also organic matter.

• The composition of black soils is 10 per cent of alumina, 9-10 per cent of iron oxide, 6-8 per cent of lime and magnesium carbonates, potash is variable (less than 0.5 per cent) and phosphates, nitrogen and humus are low.

• Constraints of black soils is narrow workable moisture, low infiltration rate, poor drainage and moisture stress, poor organic carbon, nitrogen, sulphur, phosphorus, deep soils if irrigated much prone to salinity and sodicity in subsoil and calcareous nature of these soils affects availability of many nutrients.

• Potentials of black soils is inherently fertile, predominantly used for growing cotton, millet, sorghum, soybean, pigeon pea, in Madhya Pradesh, Andhra Pradesh, Gujrat, Maharashtra and under irrigated condition sugarcane is grown in Maharashtra, Andhra Pradesh and Karnataka.

2.3. Red soils

• This type of soil is formed as a result of weathering of metamorphic and igneous rocks. The red and lateritic soils occupy 70 m ha (Figure 4). Seen mainly in low rainfall area.

• Clay enriched subsurface (Bt) horizon, weathering is more intense leads to decalcification. It is rich in potash content but lacks phosphate, manganese, humus and nitrogen content.

• Color of red due to ferric oxide. pH is 6.0-7.5. The amount of iron and aluminium are generally high (30-40%). Low CEC and BS.

• Distributed in Tamil Nadu, Madhya Pradesh, Jharkhand, Odisha, some parts of Karnataka and southeast Maharashtra, Andhra Pradesh, Goa, Union territories of Pondicherry, Dadra Nagar Haveli, Daman and Diu.

• Morphologically red soils are divided in to i) Red loam-characterised by argillaceous, clay enrichedand ii) Red earth-characterised by loose, friable top soil but rich in sesquioxide type of clay.

• Constraints of red soils are Most prone to surface crusting and hardening. Depth is a limitation in hills and hill slopes and are gravelly or skeletal in nature. Low WHC, high soil erosion potential, excessive drainage and surface runoff. Compacted subsurface restrict the root development. Poor soil fertility particularly nitrogen, phosphorus, calcium, zinc, sulphur and low CEC.

• Potential for agricultural, horticultural, and plantation crops. Support millets, ragi, paddy, ground nut, maize, soybean, gram, jute, potato, green gram, tea, cocoa, cashew, grapes, banana, papaya, mango etc.

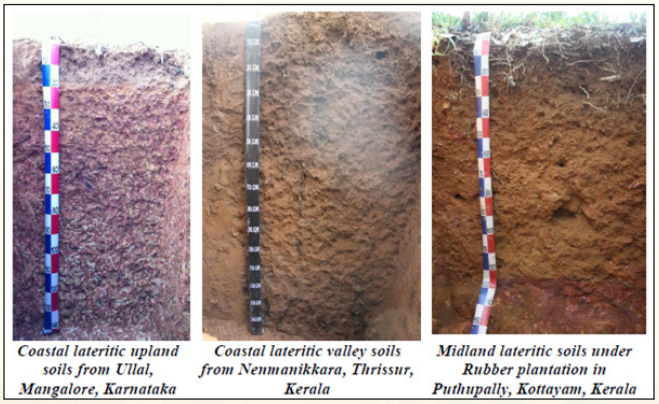
Figure 4: Red soils of Rayachoty mandal, YSR Kadapa District, Andhra Pradesh

2.4. Laterite and Lateritic soil

• The name 'Later' is Latin word which means Brick. Used for construction of buildings.

• Formed in tropical and subtropical climates with alternate wet and dry season (Figure 5). Become so soft when wet and so hard when dried.

• In the areas of high temperature and high rainfall. Formed as a result of high leaching of siliceous matter and remains sesquioxides which converts into irreversible iron and aluminium oxides.Lime and silica will be leached away from the soil. Rich in iron and aluminium and deficient in nitrogen, potash, lime, humus. Color of Red



Coastal lateritic upland soils from Ullal, Mangalore, Karnataka | *Coastal lateritic valley soils from Nenmanikkara, Thrissur, Kerala* | *Midland lateritic soils under Rubber plantation in Puthupally, Kottayam, Kerala*

Figure 5: Lateritic soils (Kumar et al., 2017)

due to iron oxide.

• Rice, ragi, sugarcane, rubber, coconut, tea, coffee and cashew nuts are cultivated mainly.

• Laterites when they dry for <2 months (Oxisols) in a year have BS- <40% and CEC <16 cmol (p+) kg^{-1}, SiO_2/Al_2O_3 ratio- <2 and Kaolinite clay minerals and gibbsite is generally present.

• Laterites when they dry for 4-5 months (Alfisols, Ultisols) in a year have BS- >40% , SiO_2/Al_2O_3 ratio- >2, both 1:1 and 2:1 typesof clay minerals and gibbsite is generally absent.

• Distributed in hill tops and plateau of Orissa, Maharashtra, Kerala, Tamil Nadu, NER, Andhra Pradesh, Karnataka, Assam

2.5. Salt-Affected soils

• In India, these soils confined to the arid, semi-arid and subhumid (dry) regions, occur on 10 m ha (Figure 6).

• There are many mineral-based and un-decomposed contents inside the earth, due to weathering, they release certain minerals such as sodium carbonate, sulphate, chloride with magnesium calcium salts. Some of the released spices get carried by rivers and mix in sub-soils of the plains making the soils saline and alkaline.

Figure 6: Sodic soils of Rayachoty mandal, YSR Kadapa, Andhra Pradesh

• This type of soil can be found in Uttar Pradesh and Punjab and also in some parts of Gujarat, Rajasthan, Maharashtra and Karnataka. Classification of salt affected soils given in Table 3. In India, only two categories of soil recognised (Bhumbla and Abrol, 1979) which are 1. Saline soils and 2. Sodic/alkali soils. Saline-alkali soils behave like saline soils. Abrol et al. (1980) pointed out that saturated soil paste pH 8.2 should be used to distinguish sodic or alkali soils from saline soils.

• Constraints are excess sodium reduces the soil productivity, soil structure gets affected, creates problem of water and nutrient availability and micronutrient deficiency.

• Potentials are sodic soils can be reclaimed by gypsum as amendment, upon partial reclamation, some sodium tolerant and semi-tolerant crops such as rice, sugar beet, rhode grass, wheat, barley, sugarcane, cotton, bajra, can be successfully cultivated, proper drainage should be provided

Table 3: Classification of salt affected soils

Class	EC (dS m^{-1})	pH	ESP	Local names
Saline	>4	<8.5	<15	Thur, shora, Khar, Kari, Loma, Pok-kali, Soulu
Saline-sodic	>4	>8.5	>15	Usar, Kallar, Karl, Chopan, Reh, Kshar, Bari
Sodic	<4	>8.5	>15	Rakkar, Bara, Usar, Karl, Chopan

2.6. Desert / arid soil

• Seen under hot arid regions on 29 m ha in western Rajasthan, southern Haryana, and SW Punjab. The desert soil is found in regions with low rainfall in an arid and semi-arid climate.

• Deposited mainly by wind activities. High salt content. Kankar or Impure Calcium carbonate content is high which restricts the infiltration of water. Nitrogen is insufficient and Phosphate is normal. Texture is sandy, The soil content has 90-95% of sand and 5-10% of clay.

• Color is pale brown to yellowish brown. pH is 7.2 to 9.2 generally 8.1 to 8.6. Salts are high but not toxic.

• Gypsum found to accumulation and forms a gypsic

horizon, need to be used with care as it forms sink holes when irrigated.

• Constraints are, a major part of the region consists of sand dunes and undulating sandy plains where water is a major constraint which holds little amount of water as such are droughty, and prone to deep percolation losses of water received from rainfall or irrigation. Poor fertility status due to high temperature applied phosphorus undergoes precipitation.

• Potentials are best suited for the grassland/pasture. Arid fruits like ber, pomegranate, pearlmillet, or pulses can be grown. During monsoon period, good amount of biomass is builtup which is used as dry fodder for animals during lean period.

2.7. Forest and hill soils

• Total forest area in India is 75 m ha (18% of TGA). Occur on Himachal pradesh, Jammu and Kashmir, Uttar Pradesh, Arunachal Pradesh, Nagaland, Assam, Meghalaya, Mizoram, Manipur, Orissa, Madhya Pradesh, Maharashtra, Kerala, and Andaman and Nicobar Islands.

• In the forest area two kinds of soils formation have been distinguished, i) soils formed under acidic conditions in the presence of acid humus and low base status (podzols) and ii) soils formed under slightly acidic/neutral and high base status conditions (brown forest soil) (Figure 7A and 7B).

Figure 7A: Brown forest soils under rubber plantations, Elamdesam block, Idukki, Kerala

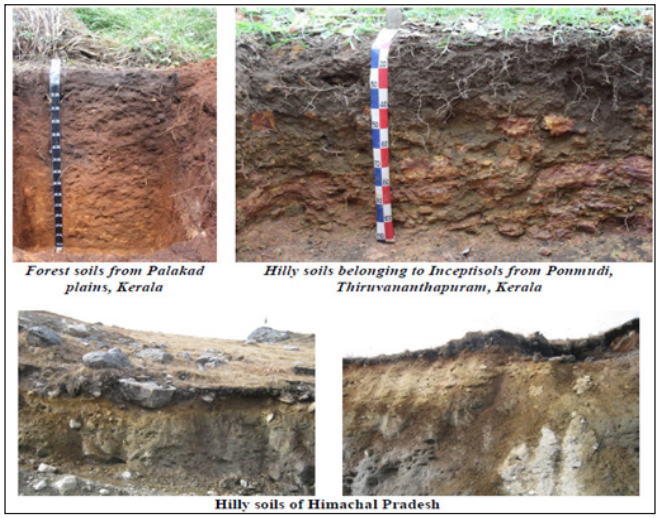


Figure 7B: Forest and hill soils (Kumar et al., 2017)

• Podzols can be seen in Dalhousi, Simla, Manali, yet they are not true Podzols (Spodosols). Podzols have pH 4.5 to 6.0, high organic matter (3-3.5%), moderately high clay (20-30%), variable CEC (10-12 cmol (p+) kg^{-1}), low BS (<50%), deficiency of P due to precipitation of P as Fe-P and Al-P.

• Brown forest soils have pH 6.0-7.0 upto 8.0, higher humus with organic matter 1-3%, moderate CEC (15-20 cmol (p+) kg^{-1}) with bases 60-90% and high biological activity.

2.8. Peaty/ marshy soils

• Peaty soils developed under areas of heavy rainfall and high humidity in Kerala and NE region (Figure 8).

• These soils with soluble salts in Kerala called as Kari. Heavy soil with black colour with 20-40% organic matter. Fine in soil texture.

• These soils when drained, the pyrites (FeS_2) is oxidised and sulphuric acid is formed resulting in pH 4.0 which

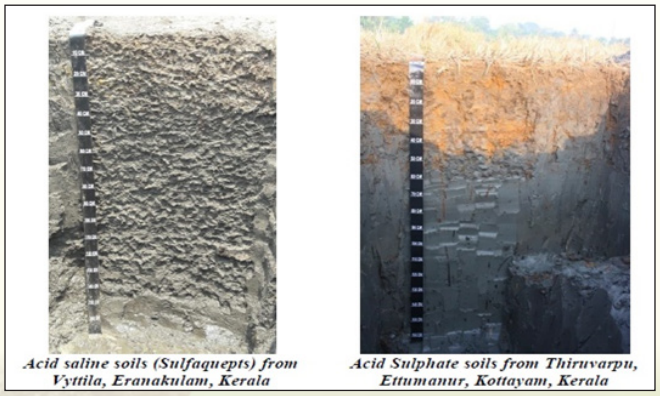


Figure 8: Peaty and marshy soils (Kumar et al., 2017)

are strongly acidic soils.

• These soils in south east Asia are called Cat-clay or Acid Sulphate soils.

• These soils can be used for cultivating paddy and pineapple which can tolerate acidity by keeping the water table above the subsoil layer where pyrite is located.

• Marshy soils are found in coastal areas of some states such as Tamil Nadu, Bihar, Almora district of Uttaranchal and Sunderbans of West Bengal mostly associated with mangrove forests.

• Marshy soils confined to depression caused by dried lake in alluvial and coastal plain areas developed under anaerobic waterlogged condition results in bluish or greyish coloured soils.

3. Conclusion

The Indian soils are largely deficient in nitrogen, mineral salts, humus and organic materials. Plains and valleys have good soil development compared to hilly and plateau. Soils range from highly fertile (alluvial and black soils) to less fertile (laterite, desert and alkaline soils). The soils have lost fertility due to continuous cultivation from hundreds of years. Nine key soil threats need to be addressed to control conversion of agricultural crop land to non-agricultural land.

4. References

Abrol, I.P., Chhabra, R., Gupta, R.K., 1980. A fresh look at the diagnostic criteria for sodic soils. International Symposium on Salt affected soils, Karnal. 142–147.

Bhumbla, D.R., Abrol, I.P., 1979. Saline and sodic soils. In soils and rice. International Rice Research Institute, Manila. 719–738.

Chandrakala, M., Srinivasan, R., Anil Kumar, K.S., Nair, K.M., Sunil, P.M., Ramesh Kumar, S.C., Srinivas, S., Hegde, R., Singh, S.K., 2017. Land resource inventory of elamdesom block, Idukki district, Kerala on 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques.ICAR-NBSS Publ. No.1049 NBSS&LUP, Nagpur.

Chandrakala, M., Srinivasan, R., Bhaskar, B.P., Sunil, P.M., Ramesh Kumar, S.C., Srinivas, S., Hegde, R., 2019. Land resource Inventory of Rayachoty mandal, YSR Kadapa district, Andhra Pradeshon 1:10000 scale for optimal agricultural land use planning, using geo-spatial techniques.NBSS Publ. No.1120, ICAR-NBSS&LUP, Nagpur.

ISSS, 2009. Fundamentals of soil science (2nd edition). Indian Society of Soil Science, , Pusa, New Delhi, India ISBN 81-903797-4-7.

Kumar, A.K.S., Lalitha, M., Shivanand, Sujatha, K., Nair, K.M., Hegde, R., Singh, S.K., Mishra, B.B., 2020. Major soil types and classification, The soils of India, Springer, ISBN 978-3-030-31080-6. 81-108.

Sehgal, J., 1996. Pedology-concepts and applications (1st edition). Kalyani publishers, ISBN 81-7096-137-8, Ludhiana, India.