Dielectric Behaviour of Indian Soil

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ABSTRACT
In this paper an attempt has been made to analyze as well as study the microwave dielectric behavior of soil in India. Soils are composed of solids, liquids and gases mixed together in variable proportions. Study of physical properties, chemical properties, dielectric properties of soil with varied organic and inorganic matter is useful in agriculture to predict quality and fertility of soil. Also it is useful for the researchers working in the field of microwave remote sensing. It has been observed that the dielectric constant of dry soil is less than three. Further it has been observed that dielectric constant of soil of different states UP, Kashmir, MH, Karnataka, WB, CG, Rajasthan, Kerala as 2.1, 5.0, 8.2,4.5, 3.5, 20.5, 10.5, 4.5,8.0 respectively. However, the relationship between soil dielectric constant and the soil physical properties is not straight forward. Soil plays a key role in various hydrological and meteorological applications. The moisture content in the soil affects the dielectric constant. The value of dielectric constant depends upon the percentage of moisture content in the soil. Soil characterization of a region is an important aspect in relation to sustainable agricultural productions.

Keywords- Microwave, Soil, Moisture Content, Dielectric, Soil Texture.

I INTRODUCTION

Dielectric properties of soil in agriculture of up gradation place pivotal role, Dielectric constant, Dielectric loss, Tangent loss, relaxation time are the key parameter, dielectric properly is observed at different frequency band such as L, S, C, X, Ku band.

For geometric upgradation is necessary to estimate as well as knowing the various type of parameter. Such as soil texture, practical density, bulk density, porosity, moisture constant, flocculation density, heat of welting, thixotropy, plasticity, soil pudding, dielectric constant, microwave brightness, temperature humus, soil air, organic composition, inorganic constitutes, emissivity, soil temperature , salinity, bound water layer, shape, size analysis, micronutrient, soil consistency viscosity, soil cracking, soil tilted mechanics, soil, cracking electrokinetic properly specific surface, soil roughness, resistivity, soil penetration dept, macro nutrient, pH, hydraulic pressure, electric conductivity, latitude, altitude, longitude, average rain, humidity, climate, session, scattering absorption ,irrigation, use of fertilizer, crop cycles, etc.
Permittivity or dielectric constant is function of electrical parameter of surface is function of electrical parameter of surface constituent, the properties of dielectric material influence its quality to absorb energy of microwave. Dielectric property critically affects the scattering the microwave energy.

Remote sensing technique are Widely used in agronomy and agriculture. Soil fertility and fertilizer are very importance for productive of grain. There are so many factors which affect the production. Such as nutrients, soil plants relationship, acidity and alkalinity, nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, iron, zinc, copper, manganese, born, chlorite, molybdenum, nickel, etc

It is well known remote sensing is the science and art of obtaining information about an object, area or phenomenon through an analysis of the data acquired by a device which is not in contact with the object area or phenomenon under investigation.

The region of spectrum composed of electromagnetic radiation, with web length between 1 mm and 1m is called the micro band. The microwave band is a valuable region for remote sensing in view of two distinctive features.

- Microwaves are capable of penetrating the atmosphere under almost all condition. Depending on the wave lengths involved.
- Microwave reflections or emissions from earth materials bear no direct relationship to their counter parts in the visible or thermal portion of the spectrum. The surfaces the appear rough in the visible maybe smooth in microwave.
- Remote sensing technique in the microwave region of electromagnetic spectrum can be classified into two categories:

(a) **Active microwave remote sensing.**
(b) **Passive microwave remote sensing.** Active system provides their own illumination, whereas passive system records the energy of thermal origin emitted from materials. Active microwave sensing systems are of two types and they are imaging sensors and non- imaging sensor. The Chhattisgarh region is located in the south-eastern part of India comprises the seven revenue districts of Raipur, Durg, Bilaspur, Raigarh, Rajnandgaon, Sarguja, and Bastar. The soils occurring in the region have been found to differ widely in theircharacteristics, colour, texture,

reactions etc. The soils of the region are divided between four locally named categories called Bhata, Matasi, Dorsa and Kanhar.

It is relevant to describe some important parameters, related to the physical properties of the soils i.e. soil texture and soil structure. Soil texture is concerned with the size of mineral particles present in the soil. Specifically, it refers to the relative proportion of the particles of various sizes in a given soil. Soil structure is the arrangement of the soil particle into groups or aggregates. These properties are helpful in determining not only the nutrient supply ability of soil solids but also .the supply of water and air which are so important to plant Life. As soils are composed of particles, it varies greatly in size and shape. Specific terms are needed to convey some idea of their textural make-up, and to give some indication of their physical properties. For this, Soil textural class-names such as sand, sandy loams, and silt loam have been used. Three broad and fundamental groups of soil.

(c) Theoretical Consideration: Soil is a dynamic natural body developed as a result and pedogenic process through weathering of rocks, composting of mineral and organic constituent processing definite chemical, mineralogical and biological properties having a variable depth over the surface of the earth and providing a medium for plant growth soil is very essential part for us the physical properties of soil depends on the amount size shape arrangement and mineral components of its particles. This property is also depending on organic matter content and pore spaces, the size of particles in mineral soil is not readily subject to change. Thus, a sandy soil remains sandy and clay soils remains clay, particles size analysis is based on a simple principle that is when soil particles are suspended in water they tend to sink because this is a little variation in the density of most soil particles, their velosity of setting is proportional to the square of the radius **"r"** of each particle thus,

$$\mathbf{V = K.r^2}$$

Where, **"K"** is a constant.

This equation is referred to as Stokes's law. According to stock the velocity of falling particles is proportional to the radius square root and not to its surface. The relation between the diameter of a particle and its setting velocity is governed by Stokes's law,

$$\mathbf{V = \frac{2}{9}\ x\ \frac{g}{n}(ds\text{-}dw).\ r^2}$$

Where, V = velocity of setting particles,
G = acceleration due to gravity,
Ds = density of soil particles,
Dw = density of water,
n = coefficient of velocity of water,
r = radius of spherical particles.

(d) Measurement of Dielectric Constant

The infinite sample method described by H M Altshuler is used for the measurements of dielectric properties. An X-band microwave bench operating at 10.45 GHz in the TE_{10} mode with a slotted section and a crystal detector used for measurements of VSWR and the shift of minima are needed in this technique. The complex dielectric constant (ε*) calculated using the relation

$$\varepsilon^* = \varepsilon' - \varepsilon''$$

$$\varepsilon^* = [1/1+(\frac{\lambda_c}{\lambda_g})^2] + [1/1+(\frac{\lambda_g}{\lambda_c})^2]\quad [R - j\tan\{k(D - D_R)\}/1 - jR\tan\{k(D - D_R)]$$

Where, λc, λg and k are cut-off wavelength, guide wavelength and wave vector respectively.

The moisture content in percentage by dry weight, Wc(%)is calculated using the following relation,

$$\mathrm{Wc}\ (\%) = \left[\frac{\text{wt. of wet soil} - \text{wt. of dry soil}}{\text{wt. of dry soil}}\right] \times 100$$

Measurements have been carried out at 10.45 GHz. This experimental set-up consists of a 2K 25 reflex klystron as the microwave source, with maximum output power of 25 mW and frequency range (8.2–12.4) GHz. The source is connected with a broadband isolator with maximum isolation of 30 dB and insertion loss of 1.25 dB. This is used to avoid interference between the source and reflected signals. After isolator a variable attenuator is used to control the power at the desired level. This is followed by a 20 dB multi hole directional coupler which is used to monitor the power level flowing through the system. A direct reading absorption type frequency meter with high Q-factor (Q ~1000) and 2.5 MHz resolution with dip ≥ 1 dB is used to measure the frequency of the signal. The detector was of square law characteristics with VSWR better than 2:1. A precession slotted line section was employed to measure the VSWR and distance. The accuracy of the distance measurement is within 0.004 cm.

The sample of soil was collected from the Northern Part of Chhattisgarh state. The soils was passed through a sieve of mesh no.50 and then collected in a metallic tray. The sample were filled and pressed manually in a 15 cm long wave-guide and it was terminated in a matched load The soil was analyzed for its texture structure and its constituents Soil texture (the relative proportions of sand, silt, and clay) is important in determining the water-holding capacity of soil.

The dielectric constant of soil sample have been measured using the following four methods

- Two Point Method ---- Laboratory Condition (in-vitro)
- Network Analyzer Method---- Laboratory Condition (in-vitro)
- Single Horn Antenna Reflectometry Method Field Condition (in-situ)
- Coaxial Cable Method in Field Condition (in-situ)

Out of these four methods two point method and network Analyzer method is suitable in laboratory condition (in vitro) whereas the other two methods can be used both in laboratory as well as in field situation. Experiments involving these methods have been conducted in our laboratory with many soil samples for standardization purposes. By measuring the dielectric constant(Using two point method), the emissivity of soil have been calculated using Fresnel reflectivity model, with the knowledge of real and imaginary part of dielectric constant, the relaxation time and relaxation frequency is computed from the Cole-Cole equation.

II CALCULATION OF EMISSIVITY PROPERTIES

If TB is the brightness temperature, T is the surface temperature and Tsky is the brightness temperature equivalent of the sky, ep (θ) is the emissivity of the surface layer γp (θ) Is the reflectively at air soil interface the brightness temperature can be written as:

$$TB = ep(\theta)T + \gamma p(\theta)T_{sky}$$

The emissivity ep (θ) can be written as

$$ep(\theta) = 1 - \gamma p(\theta)$$

In the case of smooth surface, over a homogeneous medium, γp(θ) can be obtained from the Fresnel reflection coefficient Rp(θ) as

$$ep(\theta) = |Rp(\theta)|^2$$

Then,

For horizontal polarization

$$Rp(\theta) = COS\theta - \sqrt{\varepsilon - \sin 2\,\theta\,/\,\cos\theta} + \sqrt{\varepsilon - \sin 2\,\theta}$$

For vertical polarization

$$Rp(\theta) = \varepsilon\cos\theta - \sqrt{\varepsilon - \sin 2\,\theta\,/\,\cos\theta} + \sqrt{\varepsilon - \sin 2\,\theta}$$

Where, θ is the angle of observation.

Emissivity is the very important parameter, which provides information about soil. All the natural objects such as soil with temperature above 0 K absolute are capable of all parameters i.e. emission, absorption and transmission. The emitted radiation from soil depends upon all parameters. It has been seen that the emissivity of the soil also varies with different moisture contents, as this would be very helpful for building microwave instrument for application in agriculture.

Dielectric constant is very important. In this paper dielectric constant has been analyzed. In Chhattisgarh majority of soil is Red-yellow soil. Soil has various types of properties. Soil has physical property, chemical property and geographical property. In soil constituents presents asmicro-nutrients (Fe, Mn, Zn, Cu), macro-nutrients (N, P, K, Ca, Mg), organic carbon and sodium. The effect of pH., soil melting point capacity, water holding capacity, bulk density, soil porosity, air field porosity, conductivity, TDS, frequency, volumetric water content, gravimetric water content, dielectric loss, relaxation time, tangent law, resistivity, texture affect the soil parameter. But dielectric property plays important role in microwave remote sensing. Complex permittivity is related with dielectric constant and dielectric loss.

III RESULT & DISCUSSION

Dielectric constant plays pivotal role in the farming. All soil parameters are affected by dielectric constant so it is very alarming for the production of food grains. In our country Common life is based on mainly on agriculture. So in this contest concerned scientists, pioneers, researchers are performing landmark research to fulfill needs of country. Moreover, fifteen or sixteen states are involved in such type of research. Some of the researchers are -

- From Kerala Dr. Mohan, Dr.S.Mridul, Dr. P. Mohanan and Dr. Binu Paul
- FromMaharastraV.V.Navarkhele,Dr.H.C.Choudhary,Dr.V.J.Sinde,Dr.D.V.Ahire,Dr.A.K.Kapre,

- In Madhya PradeshDr.J.P.Shukla works is very remarkable.
- Dr. T. Panda, B.B.Kar and Dr. M.C. Borah from Assom.
- From Chhattisgarh, Dr.S.K.Patel., Dr. S.K.Shrivastava, Dr,.Samir-bajpai, and Dr. U.K.Dewangan.
- Dr. Manab Chkravarty, P.R. Choudhary, Dr. V.K. Shrivastava and Gadani research in this field from Gujrat.
- From Jammu &Kashmir Dr. Haseem-Hasan, Hazarathbaland Dr.H.S.Bali works in this field.
- In Karnataka important research done by, Dr.Chetan-Bohra and Vivek-Ranjan.
- Dr. S.N.Jha, Rajeev Sharma, (CIPHET), from Ludhiana Punjab.
- From IIT Roorkee Uttarakhand Dr. D. Singh done works in this field.
- Sudip Saran (CEERI),V.K.Gupta, O.P.N.Calla,AnilKumar,R.A.Jangid,andVivek-Yadav from Rajasthan.
- From Uttar Pradesh Devendra Singh and Jitendra Behari works is very important.
- Dr.P.K.Paul and R.Mishra research is remarkable in field of remote sensing.

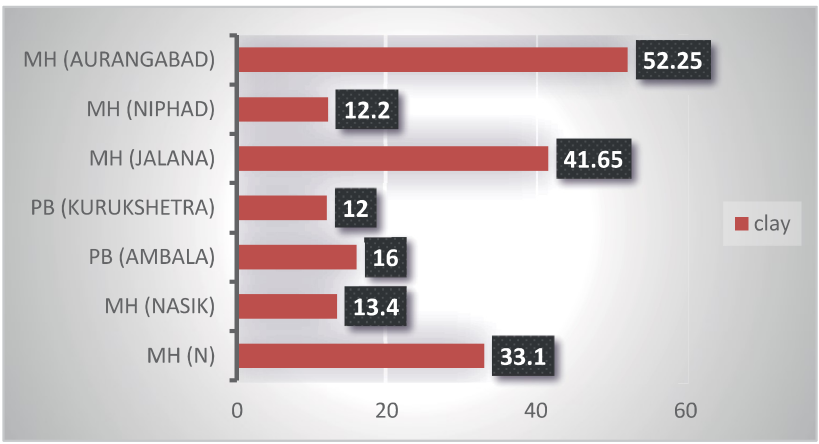

Fig. 1 : Percentage of clay within soilat various places/state of India.

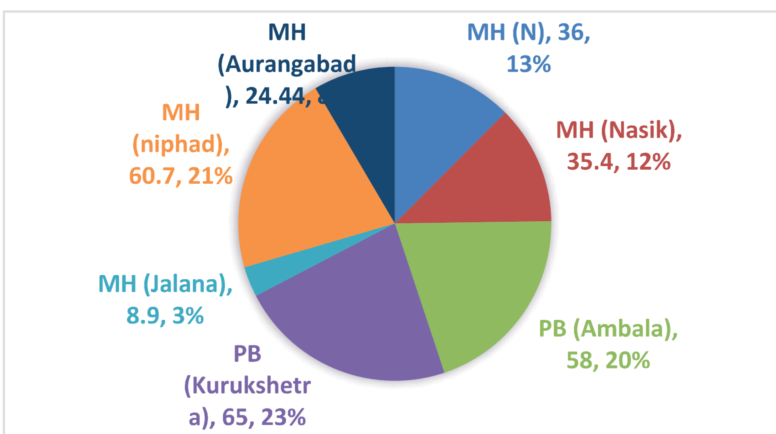

Fig. 2 : Percentage of sand in soil at various state/place in India.

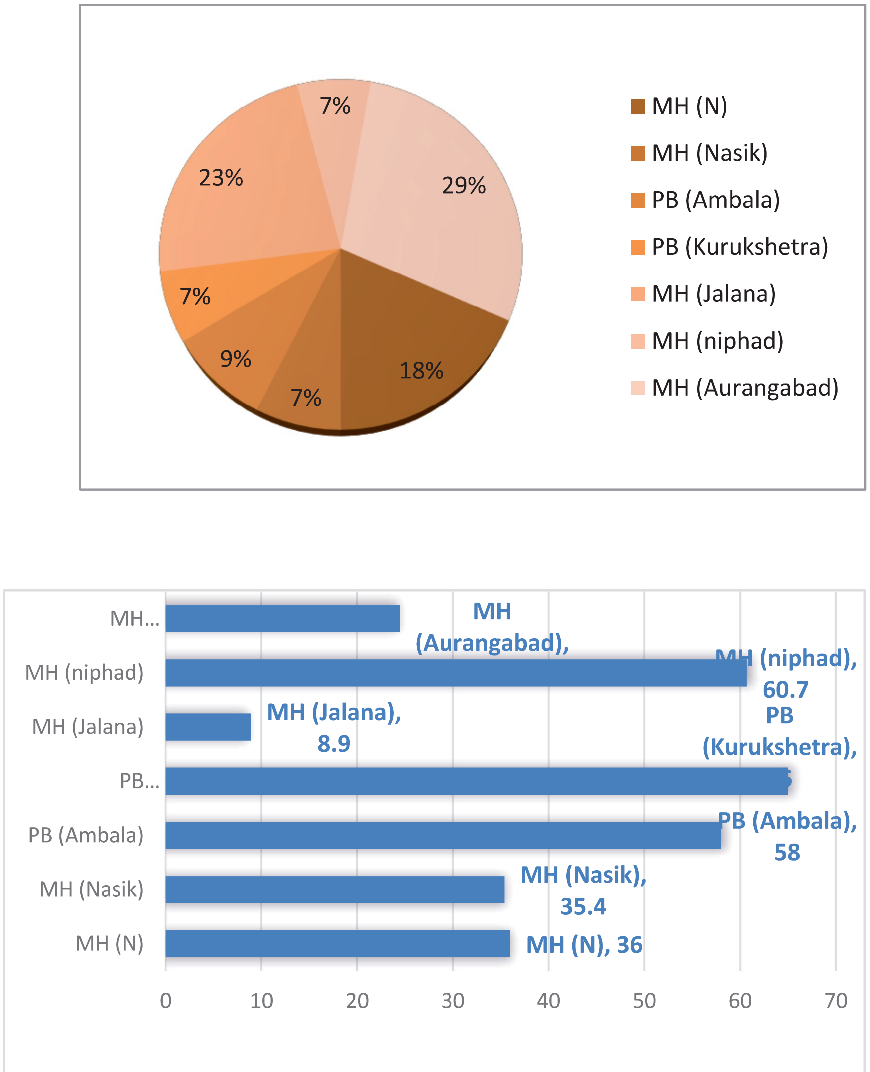

Fig. 3 : Percentage of sand in soil at various state/place in India.

Table 1
Dielectric constant of Bilaspur and Sarguja zone

S/N	SAMPLE	DRY SOIL	10%	20%	30%	40%
1	MUNGELI (B1)	3.09	7.11	9.73	13.98	18.41
2	BILASPUR (B2)	3.11	7.21	10.22	14.02	18.98
3	JANJGIR-CHAMPA (B3)	3.16	7.41	10.38	15.35	19.32
4	RAIGARH (B4)	3.19	7.53	10.68	15.65	19.62
5	KORBA (B5)	3.25	7.69	11.02	16.06	20.01
6	KORIYA (S1)	3.07	6.98	9.12	13.10	18.21
7	AMBIKAPUR (S2)	3.08	7.14	10.01	13.94	18.72
8	BALRAMPUR (S3)	3.11	7.30	10.23	15.20	19.23
9	SURAJPUR (S4)	3.14	7.42	10.54	15.41	19.48
10	JASHPUR (S5)	3.17	7.59	10.99	15.63	19.72

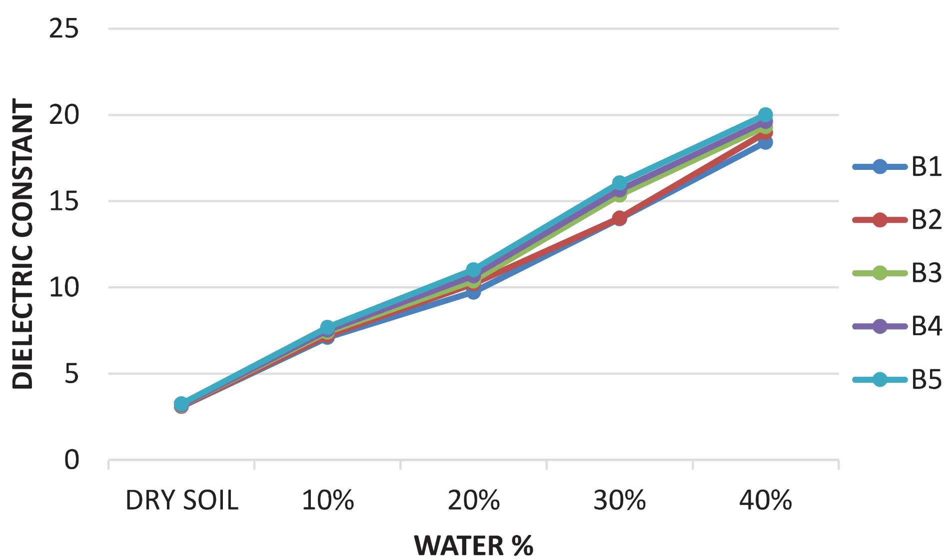

Fig. 4 : dielectric characteristics of soil in Bilaspur zone

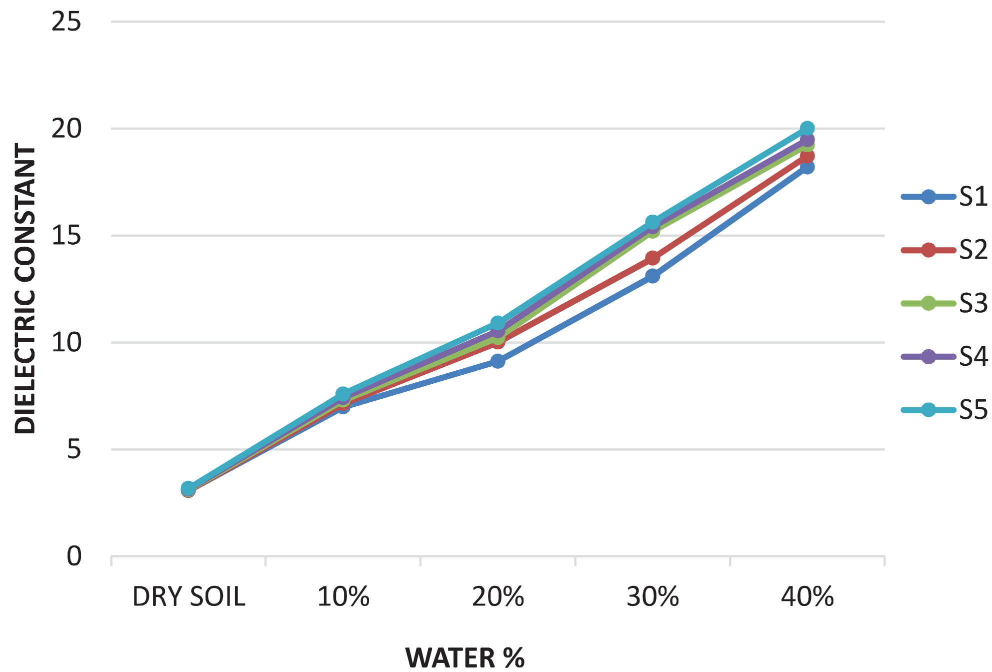

Fig. 5 : dielectric characteristics of soil in Sarguja zone.

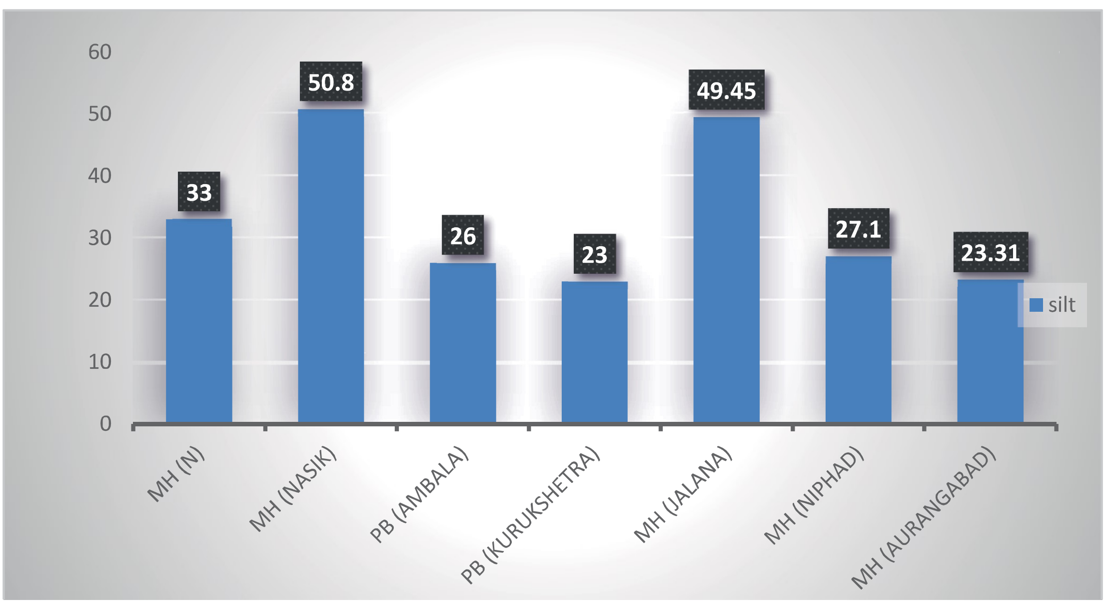

Fig. 6 : percentage of silt within soil at various places/state of India

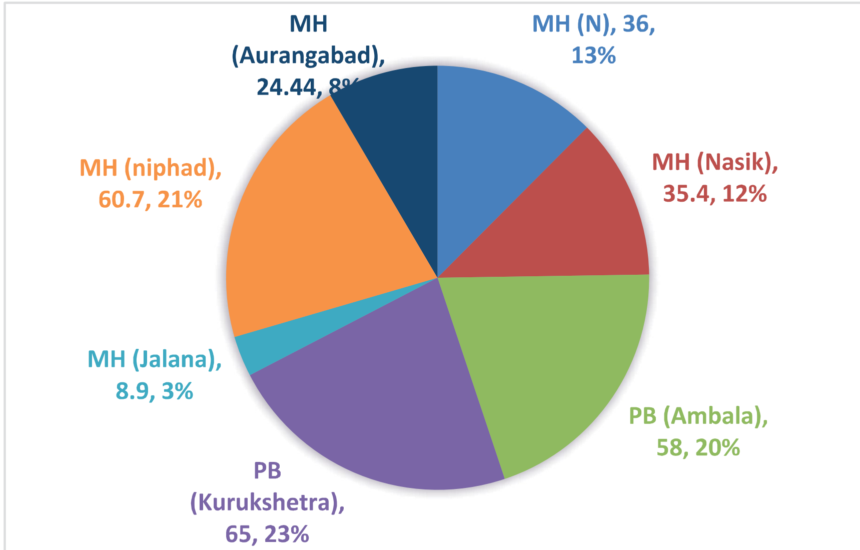

Fig. 7 : percentage of sand in soil at various state/place in India.

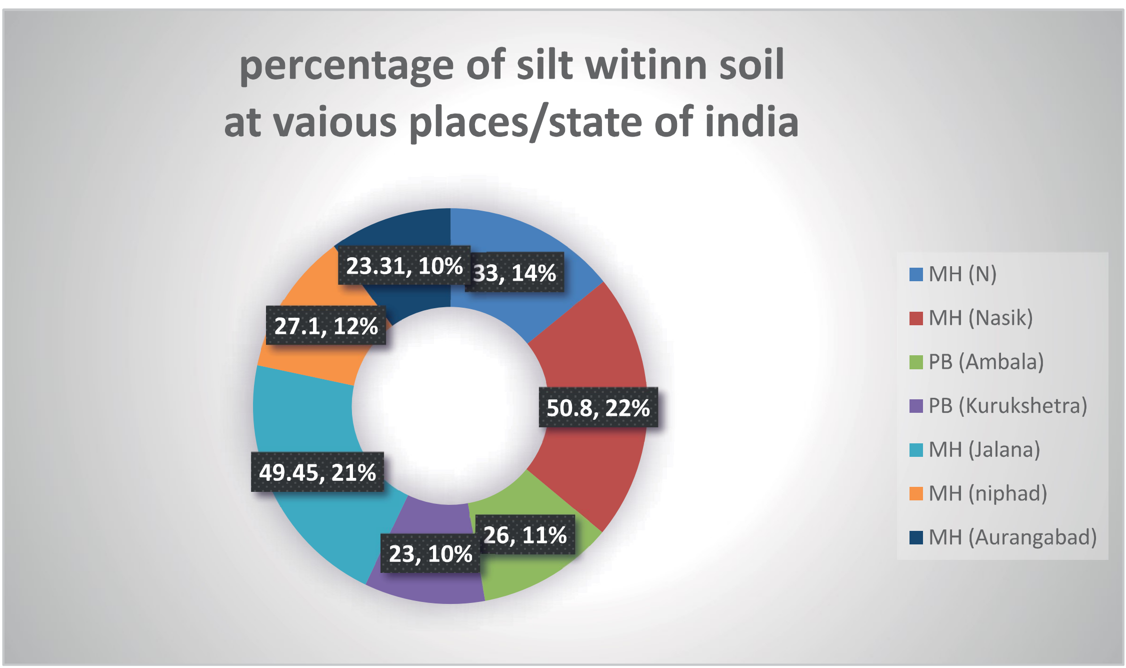

Fig. 8 : percentage of silt within soil at various places/state of India.

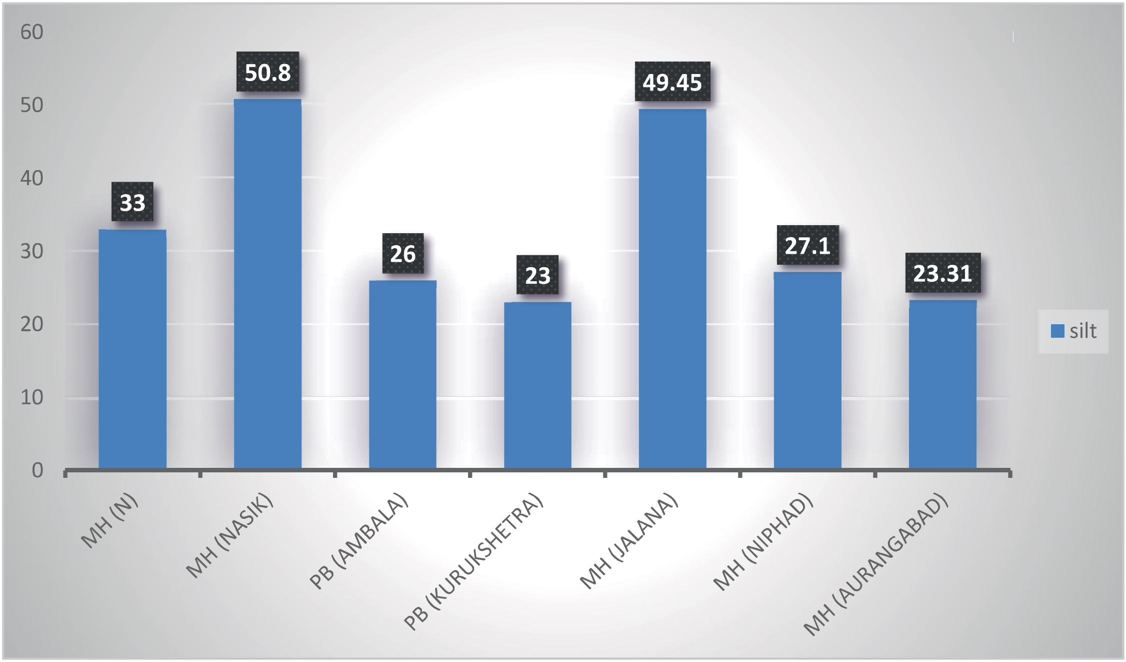

Fig. 9 : percentage of silt within soil at various places/state of India.

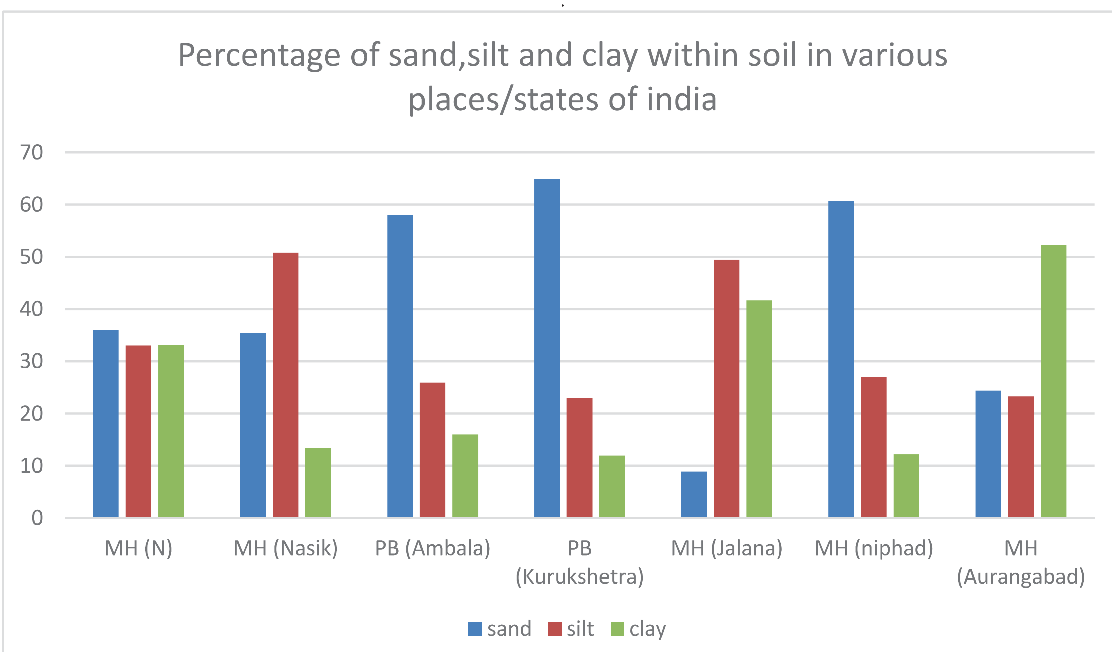

Fig. 10 : Percentage of sand, silt and clay within soil in various places/states of India.

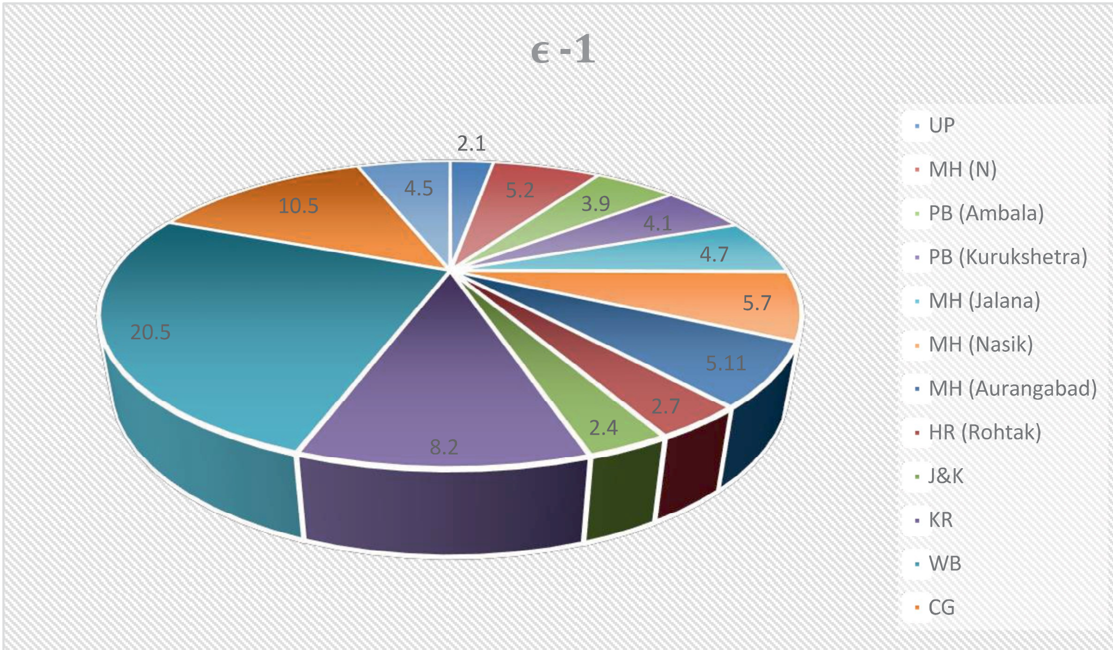

Fig. 11 : Percentage of" ϵ -1" within soil in various places/states of India.

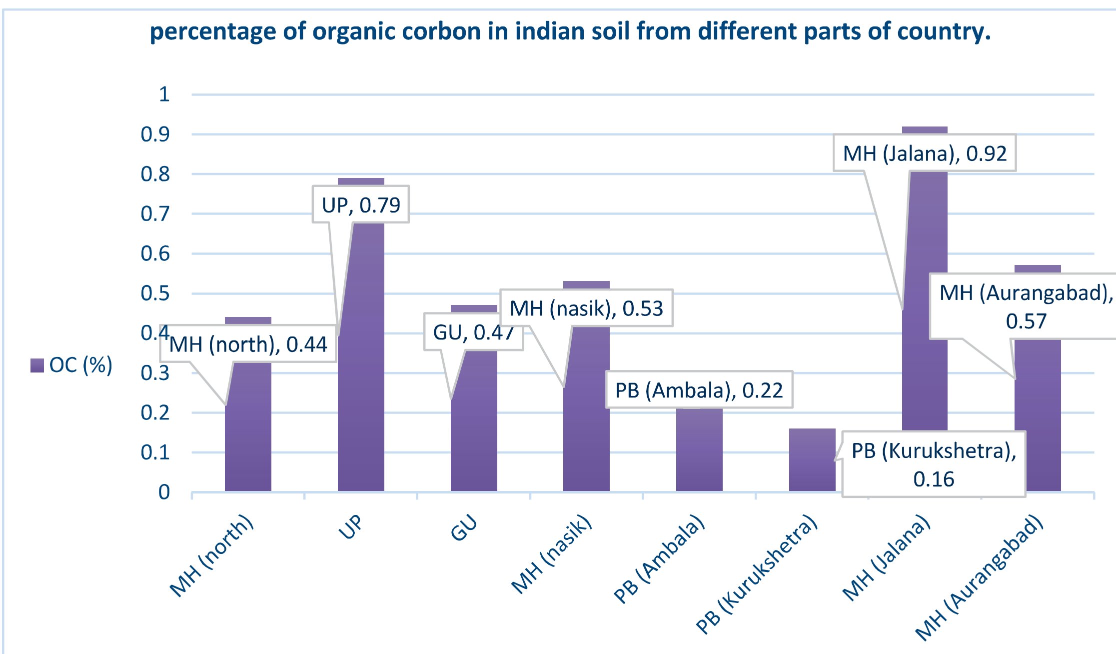

Fig. 12 : percentage of organic carbon in Indian soil from different parts of country.

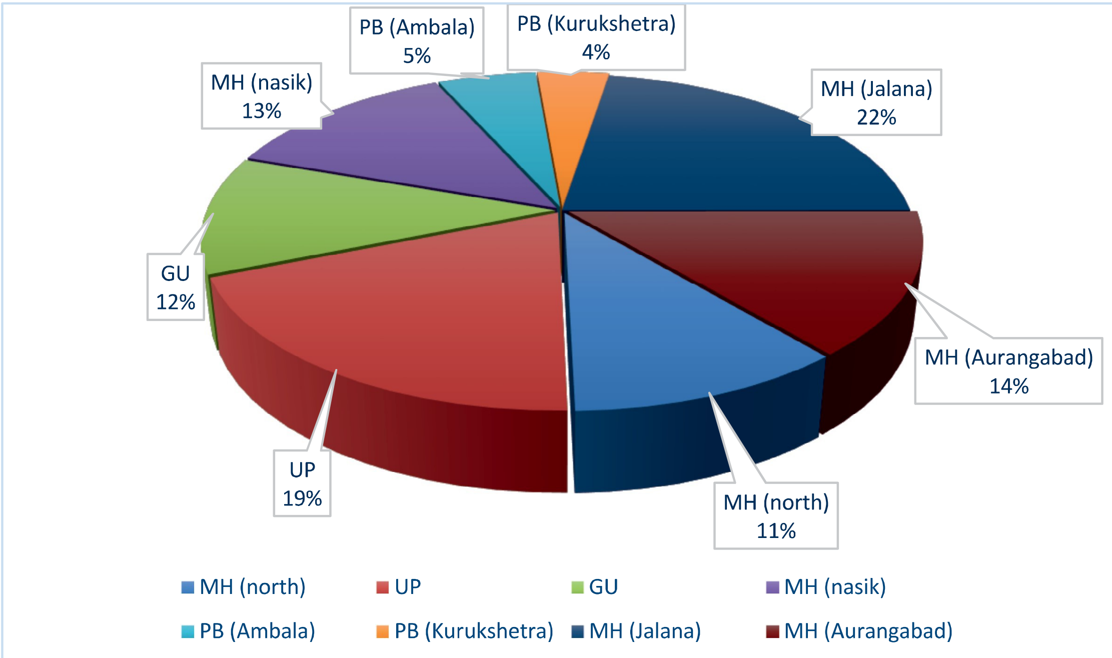

Fig. 13 : percentage of organic carbon in Indian soil from different parts of country

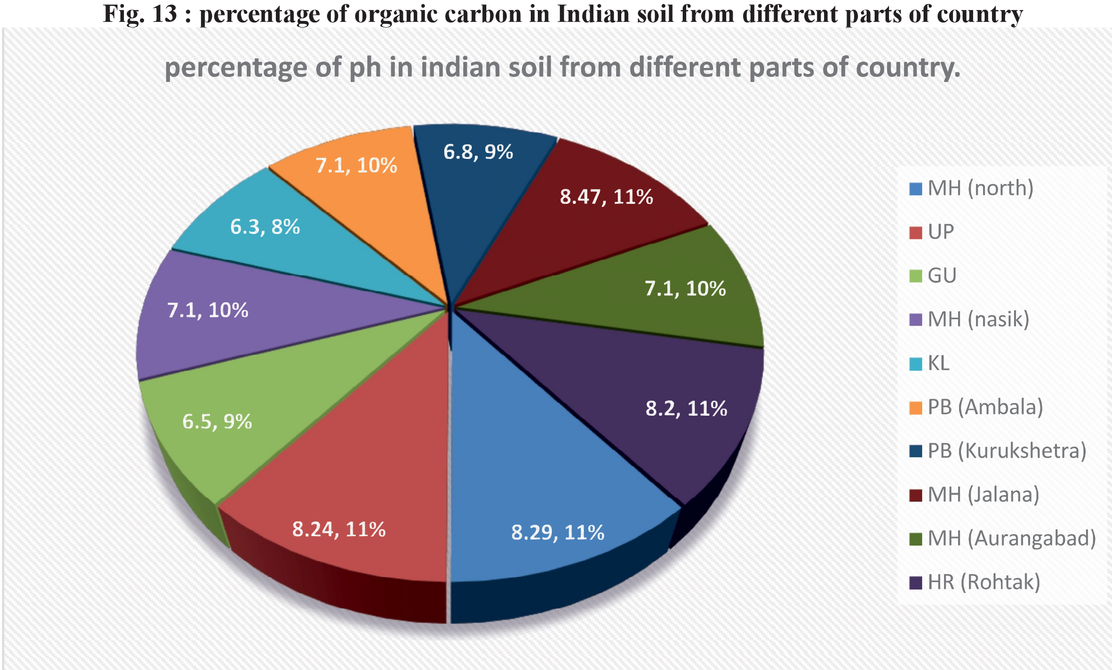

Fig. 14 : percentage of pH. in Indian soil from different parts of country

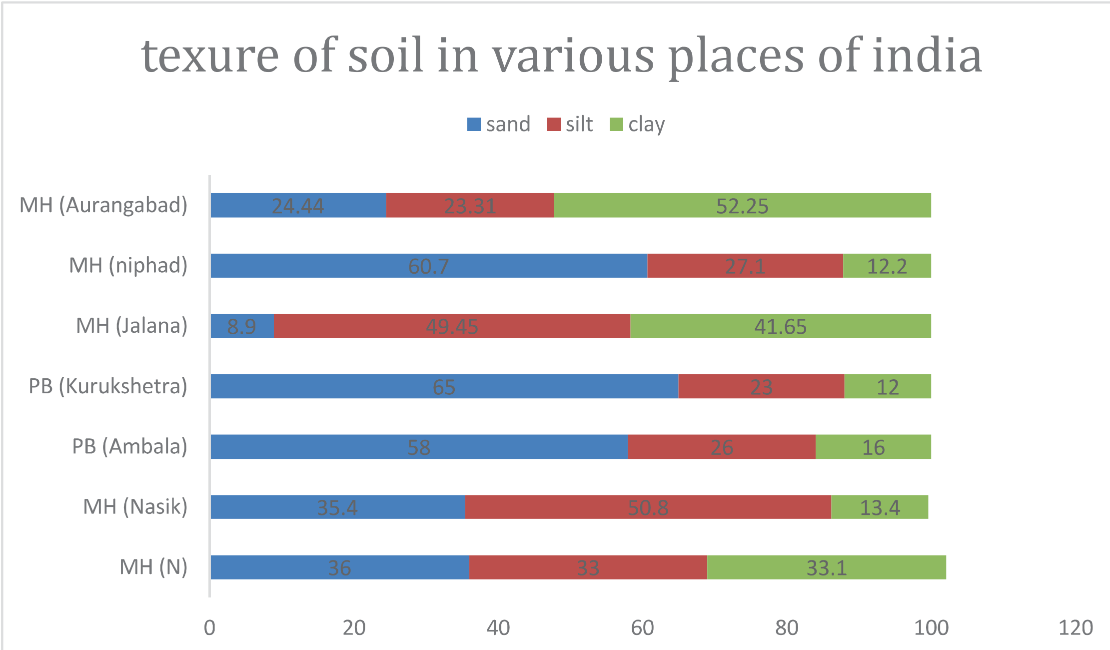

Fig. 15 : texture of soil in various places of India.

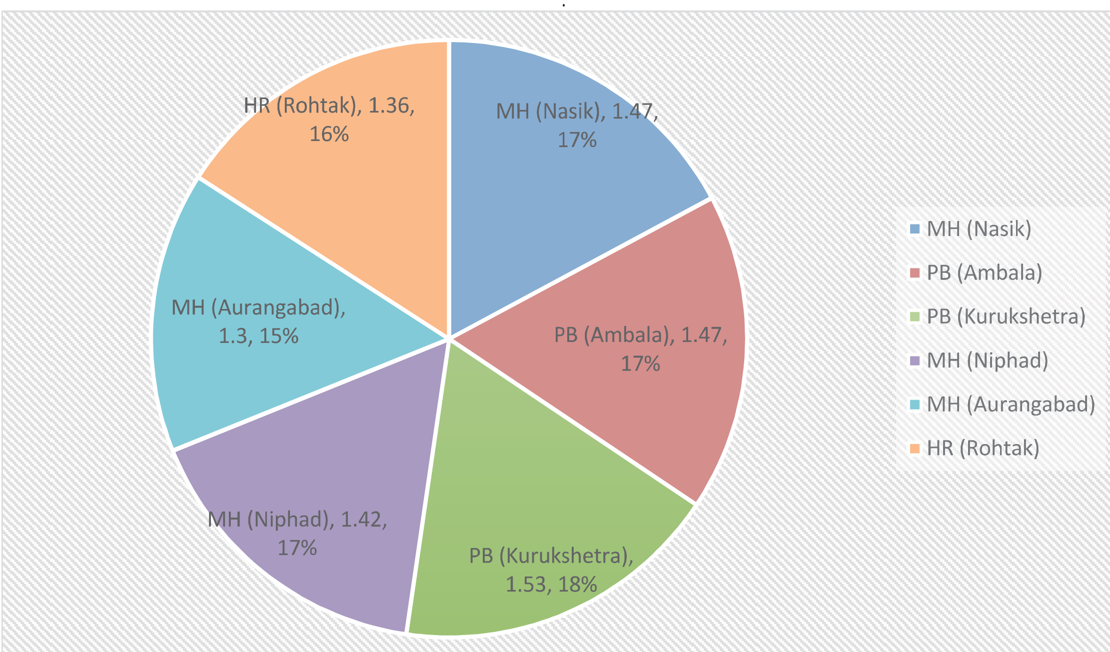

Fig. 16 : Bulk density (mgm^{-3}) in soil in various places of India.

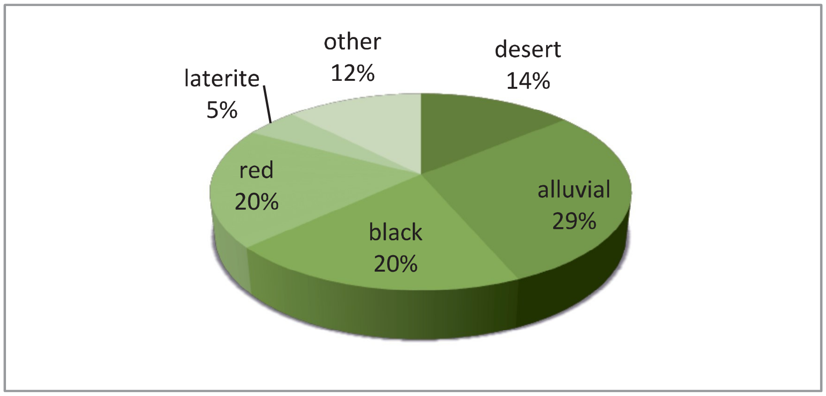

Fig. 17 : Percent of various soils in India.

IV CONCLUSION

Study of physical properties, chemical properties, dielectric properties of soil with varied matter is useful in agriculture to predict quality and fertility of soil. Also it is useful for the researcher working in the field of microwave remote sensing. The a.c. Conductivity and relaxation time depend upon the dielectric loss, which represent attenuation and dispersion. The dielectric properties of the solid dielectrics in the form of fertilized soil are useful in understanding the structural behaviour of soil.

These studies are useful for increase the fertility of soil. Complex permittivity is sensitive to changes in lead salt concentration in soil. In general, the remote relative permittivity at dielectric dispersion frequency decreased, whereas the loss factor increased with an increase in lead concentration. This indicates that complex permittivity can be used to monitor lead concentration in soil. When common salt is added to brown medium fine sand in different percentage in dry condition and compacted, the resulting dry density shows a gradual increase in value with increase in salt content.
The following conclusions have been given below –

- Electric conductivity slowly increases with dielectric constant.
- Increasing the percentage of sand, Electrical conductivity decreases.
- Increasing the percentage of silt, Electrical conductivity increases.
- Increasing the percentage of silt, Electrical conductivity sharply increases.
- Increasing the percentage of clay, dielectric constant increases.
- Increasing the porosity, Electrical conductivity increases.
- Increasing the bulk density, Electrical conductivity decreases.
- Increasing the porosity, dielectric constant randomly increases.
- Increasing the bulk density, dielectric constant decreases.
- Increasing the pH, the value of Electrical conductivity decreases.
- Increasing the value of pH, dielectric constant decreases, but at the pH value of 7 the dielectric constant is high.
- Increasing the value of nitrogen electrical conductivity shortly increases.
- Increasing the value of phosphorous the electrical conductivity increase.
- Increasing the value of potassium, the value of electrical conductivity increase.
- Increasing the value of calcium, the value of electrical conductivity gradually increases.
- Increasing the value of calcium, the value of electrical conductivity Gradually increases.
- Where as in the black soil increasing the value of nitrogen, phosphorous, potassium, calcium, and magnesium, the dielectric constant gradually increase.

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