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Estimation of Dielectric Constant of Soil of Chhattisgarh State

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Abstract:

In this paper an attempt has been made by the authors to estimate dielectric constant of soil of Chhattisgarh state. There are a lot of nutrients but eighteen elements enrich the supportive environment. The parameters such as moisture content, pH, electrical conductivity, organic carbon, soil texture, macronutrients, micronutrients, affect the dielectric behaviour of soil. The samples are collected from Kota, Bilaspur; Niyanar, Jagadalpur; Patan, Durg; Sejbahar, Raipur; and

Bhagwanpur, Ambikapur then after result deta have been analyzed. The different values have been shown for different parameter, percent of sand, silt, clay. It has been seen that the value of dielectric constant of dry soil has been found in between 3.06 to 3.17. It has been seen that the value of dielectric constant at 10% moisture has been estimated in between 6.78 to 6.93. It has been seen that the value of dielectric constant at 20% moisture has been estimated in between 11.03 to 11.17. It has been seen that the value of dielectric constant at 30% moisture has been calculated in between 16.69 to 16.98. It has been seen that the value of dielectric constant at 40% moisture has been estimated in between 26.1 to 26.7. Further it has been concluded that dielectric constant is very important for production of agriculture.

Keywords: Dielectric constant, moisture content, agriculture, soil texture, soil

Introduction:

Chhattisgarh is one of the youngest states of India. Chhattisgarh is the 26th State of India. Chhattisgarh is located in the heart of India. And shares its borders with six states of the country, U.P. to the north, Jharkhand to the north-east, and Odisha to the east, M.P. to the west and north west. Maharashtra to the south-west and A.P. to the south east. Chhattisgarh is located in the central part of India which is mentioned by *Patel Lakhapati (2021)*. Total geographical area 136034.28 sq. km. Jagadalpur is the largest district (17016.04 sq. km) while Kawardha is the Smallest (3958.01 sq. km) in area. The climate of Chhattisgarh is mainly subtropical, humid and Sub-humid. The average annual rainfall in Chhattisgarh is 1405.3 mm. up to 2022. Chhattisgarh has at least different types of soil. In the district of Bilaspur, Surguja, Durg, Raipur and Baster are red and yellow loamy soil is dominant both are low in nitrogen and humus content. A major part of paddy production comes from this region. In the hill ranges, the soil is sandy loam. Which is also suitable for paddy. Laterite soil is good for cereal crops. While the black soil is the best suited to cotton, wheat and gram.

Physical properties and chemical properties affect the production of agriculture. Soil composition depends on size of particles on the basis of particle size. It is generally called Kanker, balu, dhela, and Bhurbhura. Again on the basis of above particle sandy soil, loam soil, and clay soil are decided. The particle of sand is in

big size which is described by *Narayan Rajeshwari (2011)*. So flow of water is very high due to very small particle. In clay soil the flow of water is very slow. Agriculture is a human activity involving planned utilization of land soil and water for the growth of plants and animal to meet the basic requirement of food and clothing although agriculture is different from pastoral forming i.e. the practice of breeding and rearing of certain herbivorous animals: the term agriculture is derived from the lattin word agriculture which literally means "care of soil". Agriculture is the pivotal and most basic productivity of human society. Agriculture production in an area is influenced by several physical and economic factors, and largely by an interaction between those two set of factors, climate, soil and relief in the first group and land tenure, scale of operation, marketing transport, labour, capital and government policies in the second group are important factors exercising influence an agriculture climate is very import for soil suitable temperature and rainfall condition are essential for plant growth most plants need a minimum temperature of 5^{o}-7^{o}C before growth commences. In marginal areas of cultivation where the length of growing season is scarcely long enough for cultivation of crops, frost causes serious damage. Sufficient amount of sunshine in also necessary for plant growth. Cloudy summers often cause delay in ripening and harvesting of crops in temperate region, while persistent cloud cover and reduced amount of direct sunshine in the equatorial regions may prevent the double cropping. Rainfall is a significant factor in agriculture excess or deficiency in rainfall causes severe crop losses winds also affects farming activities in many ways which is focused by *Calla O.P.N. et al. (2004)*. It is well known that the word is derived from the Latin word solum. In general, soil refers to the loose surface of the earth as distinguished from solid rock. It is the material that nourishes and supports growing plants. Soil is really key part of human being as well as animal. Without soil it cannot be existence of environment. There are different variants of soil in India as well as world. Every state has specific properties of soil. Soil involvement is production in very important. Wet soil has dielectric constant. Parameters electrical dipole, ionic and conduction affect the dielectric properties. Soil is now homogeneous material and in this cost composition of material also affects the dielectric properties. Due to molecular movement composition of material varies. The dielectric behaviours of soil are function of its naturally available chemical constituents such as sand, silt, clay, sodium, potassium, carbon, iron, etc. Dielectric properties are also affected by soil texture which is demonstrated by *Shrivastava A.K. and Pandey Ashutosh*

(2021). The value of pH indicates the acidic or alkaline level, it has been observed by the black soil of India, formed by basaltic parent rock. Pores in soil are very important. There is pore in moisture free soil which can be gradually changed by water, through contact with water. Pores are varied with size of particles. The role of capillary force is important in pores. Thus there are three phase systems; soil phase, liquid phase, and gaseous phase. Soil help for plant growth in many ways as enriches the amount and condition of porosity. The structure of soil checks the amount of water and air exist in soil, it helps tillage practices, structure of soil controls runoff and erosion keeping in mind the relation of EMW energy with soil the dielectric properties or dielectric permittivity of the materials involved are of utmost importance. Soil is very important for sugarcane cultivation. Soil is very complex bodies, and different soil exhibits many obvious differences in composition and general makeup which is explained by *Mohan Rajesh (2015)*. They all contain four main components in which the various reactions and processes of the soil occur, viz. 1. Material matter, 2. Organic matter, 3. Soil moisture, 4. Soil air. The mineral matter may be regarded as furnishing the selection of the soil. This consists of materials of varying sizes, ranging from rock fragments and large pebbles to minute particles of silt and clay. It also provides inorganic colloidal material which is of great importance in determining many of the characteristics properties of soils. The organic matter consists largely of the remains of plant residues which have undergone decomposition in the soils giving rise to the soil humus. It may be divided into two classes in the soil that which is only partially decomposed and in which the structural features of the original plants can be recognized, and that which has lost its original structure and become structure less amorphous. This second or structure less form is the true humus and possesses the typical colloidal properties associated with soil organic matter. The organic matter is the seat of the biological activities in the soil. The mineral particles and the organic matter may be pictured as intimately mixed in the soil, the colloidal portions of clay and humus coating the solid particles of minerals matter. The particles in the soil, being of varying sizes will have spaces of varying sizes between them. These are known as pores and the sum total as the pore space of the soil. It is this that provides the accommodation for soil moisture and soil air. It will be evident that the proportions of moisture and air in the soil will show a universe relationship, when the moisture content is high, the proportion of air will be low and vice versa. Normally, when the soil is not saturated with water, the soil moisture can be regarded as bathing the soil particles

and carrying in solution the soluble materials of the soil. In connection with the general arrangement of the main soil components it is necessary to refer to the structural peculiarities' of soils. It is obvious to any observer that the packing of the solid particles in a given soil varies considerably according to the state of moistures. This is most obvious in clay soils or in soils containing large percentages of organic matter.

The quantity of micronutrient element has been given in table:

Table 1: Compound & Micronutrient element

Compound	Micronutrient element
Copper Sulphate ($CuSO_4.5H_2O$)	25.45% (Cu)
Zinc Sulphate ($ZnSO_4.7H_2O$)	22.75% (Zn)
Sodium Boret ($Na_2B_4HO_7.10H_2O$)	11.33% (B)
Manganese Sulphate ($MnSO_4.H_2O$)	32.47% (Mn)
Sodium Molybdenum	39.62% (Mo)

It is well known that soil is very very important for production of desired production. It is essential to analysis as well as understand the construction & composition of soil on the basis of particles size.

The composition of soil is given in table:

Table 2: Composition of soil & Particles size of soil

Structure of soil	Clay(<0.002mm)	Sand (0.5-2.00mm)	Silt(0.002-0.5mm)
Clay	40% or above	<45%	<40%
Loamy	7-27%	52%	25-50%
Sandy	<15%	<70%	——
Sandy- clay	30% or above	45% or above	——
Sandy-clay-loam	25-30%	45% or above	<28%
Sandy-loam	<20%	50%	——
Silt-loam	12-27%	——	<30%
Silt-clay-loam	27-40%	<20%	remaining part

Sampling of soil:

Soil sampling is very key process in any research process. Soil sample is a group of parts, objects that are taken from a big area for determining or testing.

Fig. 1: Types of Sampling Methods

Fig. 2: Soil sampling tools & sieve analysis and wet soil analysis

Physical Properties:

Properties of soil depend on the size, shape, amount arrangement and mineral composition of its constituents as, Soil texture, Soil structure, Surface area, Soil density, Soil porosity, Soil colour and Soil consistency.

Stoke's law: The speed and velocity of a falling constituents is proportional to the radius square and not to its surface which is cited by *Pithori Suryaraj (2018)*.

$$V = \frac{2}{9} \times \frac{g(ds - dw)r^2}{n}$$

Table 3: Soil Texture

S.No.	Soil Separate	Diameter range (mm)
1.	Course Sand	2.00 to 0.20
2.	Fine sand	0.20 to 0.02
3.	Silt	0.02 to 0.002
4.	Clay	Below 0.002

Table 4: Surface Area

Soil particle	Size (microns)	Surface area
Gravel	2000-20,000	0.1-1.0
Coarse sand	600-2,000	1-3.0
Fine sand	60-200	10-30
Silt	2-60	30-1000
Clay	<2	> 1000

Table 5: Density of Soil

Texture class	Bulk Density	Pore Space(r.)
Sandy soil	1.6	40
Loam	1.4	47
Silt loam	1.3	50
Clay	1.1	58

Table 6: Compound and amount of micronutrients

Compound	Amount of Micronutrients
Copper Sulphate ($CuSO_4.5H_2O$)	25.45% (Cu)
Zinc Sulphate ($ZnSO_4.7H_2O$)	22.75% (Zn)
Sodium, Boret, Suhaga	11.33% (B)
($Na_2B_4HO_7.10H_2O$	-
Manganese Sulphate ($Mn_5O_4.H_2O$)	32.47% (Mn)
Sodium Molybdenum	39.62% (Mo)

Table 7: Soil structure on the basis of percent of different size of soil particles

Soil Structure	Clay (<0.002mm)	Sand (0.05-2.00mm)	Silt (0.002-0.05mm)
Clay	40% or high	<45%	<40%
Loamy	>-27%	52%	25-50%
Sandy	<0.51%	<70%	-
Sandy-clay-loamy	25-35%	45% or high	<28%
Sandy-loam	<20%	50%	-
Silt-loam	<12-27%	-	<30%
Silt-clay-loam	<27-40%	<20%	Remember part

Table 8: Nutrient elements & Exploitation

Nutrients Elements (for high micronutrients element)	Exploitation (Kg/100 tan sugarcane)
Nitrogen (N)	67-308
Phosphorus (P_2O_5)	26-79
Potash (K_2O)	134-313
Calcium (CaO)	74-181
Magnesium (MgO)	34-49
Sulphur (S)	20-50
Micronutrients elements (gm/100)	1756-3402
Iron elements (Fe)	1122-1330
Manganese (Mn)	387-479
Zinc (Zn)	138-124
Copper (Cu)	-

Table 9: Material & Relative Dielectric Constant

S.N.	Material	Relative Dielectric Constant
1	Acetic acid	6.2
2	Air	1
3	Alcohol, ethyl (grain)	24.55
4	Alcohol, methyl(wood)	32.7
5	Amber	2.6-2.7
6	Asbestos 03	4
7	Asbestos fibre	3.1-4.8
8	Asphalt	2.6
9	Bakelite	5
10	Barium fitanate	100
11	Benzene	2.284
12	Calcite	8
13	Calcium carbonate	8.7
14	Fibre	5
15	Glass	5.0-10.0
16	Glycerin	42.5
17	Cellulose	3.7-7.5
18	Cement	2
19	Cotton	1.3
20	Ebonite	2.7
21	Paper	3.3-3.5
22	Paraffin	2
23	Polyimide	3.4
24	Polystyrene	2.55
25	Polyvinylchloride	3.18-4.5
26	Mica	4
27	Nylon	3.4-22.4
28	Oil, linseed	3.4

29	Oil, mineral	2.1
30	Oil, olive	3.1
31	Oil, petroleum	2.0-2.2
32	Oil, silicone	2.5
33	Oil, sperm	3.2
34	Oil, transformer	2.2
35	Slate	7
36	Sulphur	3.7
37	Tinantimonide	147
38	Tin telluride	70
39	Porcelain	4.0-8.0
40	Potassium niobate	700
41	Quartz	5
42	Quarty, crystalline	4.5-4.6
43	Quarty, fused	3.8
44	Rubber	2
45	Ruby mica	5.4
46	Salt	5.9
47	Selenium	6
48	Silicon	11.8
49	Silicon Carbide (basic)	10.2
50	Silicon dioxide	4.5
51	Silicone	3.2
52	Silicone oil	2.7-2.8
53	Skin	33-34
54	Tobacco	1.6-1.7
55	Tongue	38
56	Uranium dioxide	24
57	Vacuum	1
58	Vaseline	2.16

59	Vinylite	2.7-7.5
60	Water	80.4
61	Water distilled	34
62	Water, ice -30°C	99
63	Water, liquid - 0°C	87.9
64	Water, liquid - 100°C	55.5
65	Water, liquid - 20°C	80.2
66	Water, liquid - 40°C	73.2
67	Water, liquid - 60°C	66.7
68	Water, liquid - 80°C	60.9
69	Wax, paraffin	2.1-2.5
70	Wood dry	1.4-2.9
71	Soil	44
72	Soil dry	3.01

Dielectric constant of soil:

The table represent the real and imaginary part of dielectric constant at different moisture level (0%, 10%, 20%, 30%, 40%). Moisture content of soil is an important parameter that influences the properties of soil.

Table 10: Dielectric constant and dielectric loss at moisture content (0%, 10%, 20%, 30%, 40%)

S.No.	Sample	Real part of dielectric constant					Imaginary part of dielectric constant				
		Dry soil (0%)	10%	20%	30%	40%	Dry soil (0%)	10%	20%	30%	40%
1	S_1/ Kota, Bilaspur	3.06	6.78	11.03	16.69	26.1	0.10	0.20	0.30	1.2	1.11
2	S_2/ Niyanar, Jagadalpur	3.08	6.81	11.07	16.78	26.3	0.13	0.18	0.32	1.5	1.24
3	S_3/ Patan, Durg	3.11	6.85	11.11	16.87	26.5	0.17	0.20	0.34	1.7	1.33
4	S_4/ Sejbahar, Raipur	3.15	6.91	11.15	16.93	26.7	0.21	0.20	0.36	1.9	1.39
5	S_5/ Bhagwanpur, Ambikapur	3.17	6.93	11.17	16.98	26.11	0.25	0.21	0.38	1.11	1.44

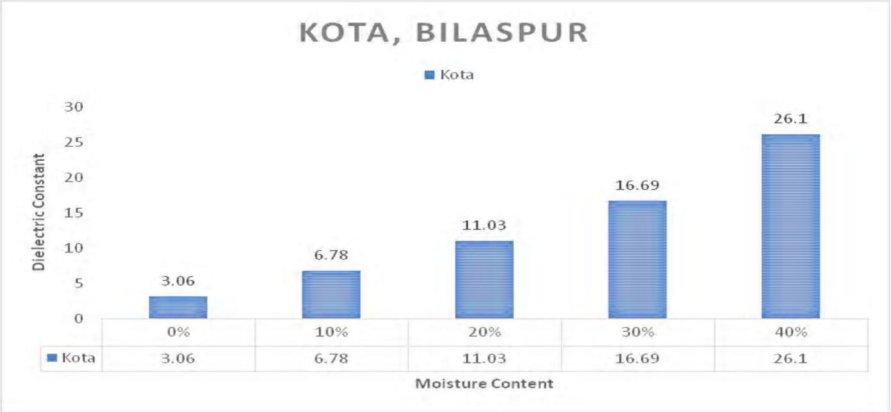

Fig. 3: Dielectric Constant of Kota, Bilaspur

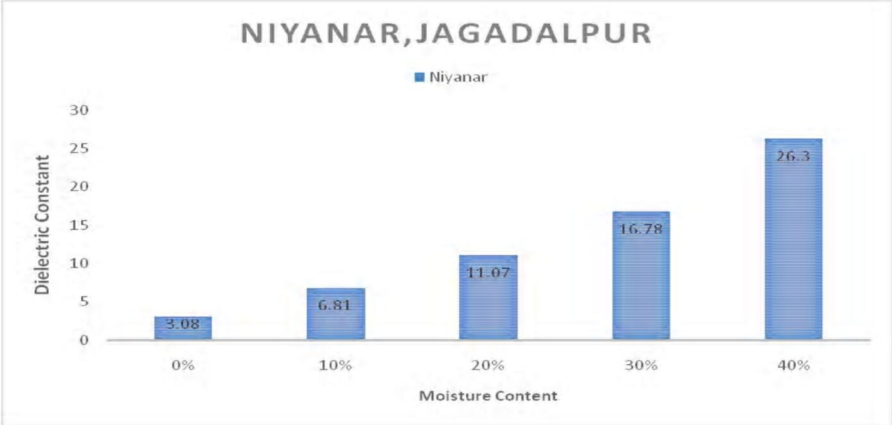

Fig. 4: Dielectric Constant of Niyanar, Jagadalpur

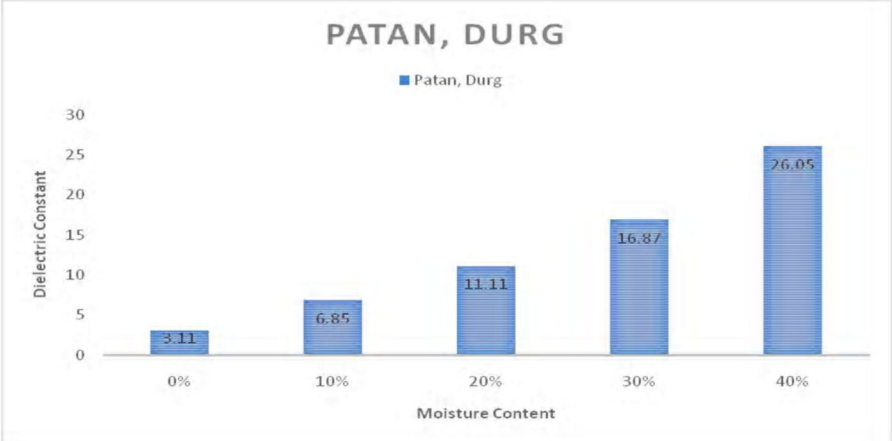

Fig. 5: Dielectric Constant of Patan, Durg

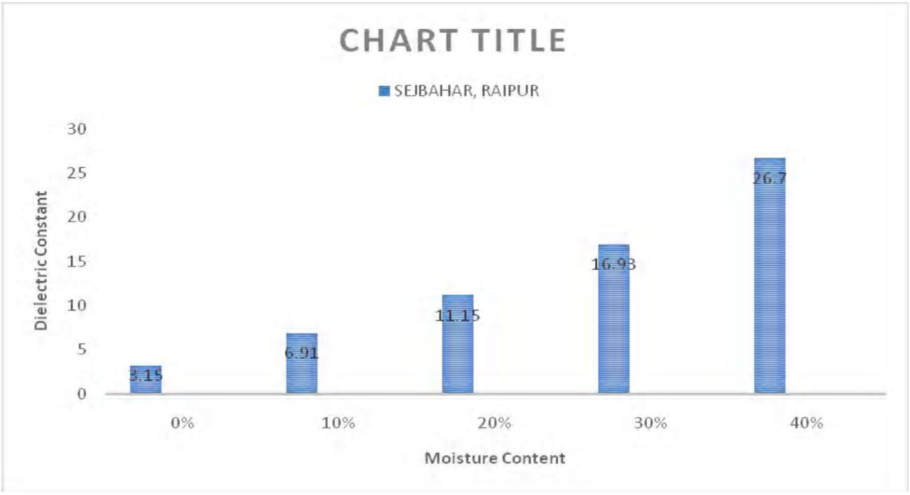

Fig. 6: Dielectric Constant of Sejbahar, Raipur

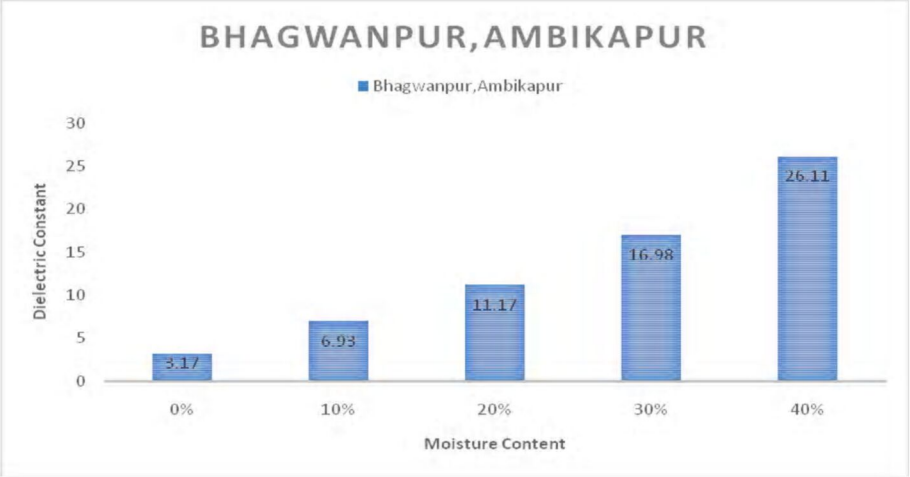

Fig. 7: Dielectric Constant of Bhagwanpur, Ambikapur

Result & discussion:

Soil is really key part of human being as well as animal. Without soil it cannot be existence of environment. All states have specific properties of soil. Soil involvement in production is very important. There are several properties of soil such as physical properties, chemical properties and geographical properties. The available nutrients play important role in the production of food grains and also in agriculture. There are a lot of nutrients but eighteen elements enriches the

supportive environment. The parameter such as moisture content, pH, electrical conductivity, organic carbon, soil texture, macronutrients, and micronutrients affect the dielectric behaviour of soil. The samples are collected from Kota, Bilaspur; Niyanar, Jagadalpur; Patan, Durg; Sejbahar, Raipur; and Bhagwanpur, Ambikapur then after result deta have been analyzed. The different values have been shown for different parameter in relation to percentage of sand, silt, clay. It has been observed that the value of dielectric constant of dry soil vary in between 3.06 to 3.17. Again, it has been found that the value of dielectric constant at 10% moisture is in between 6.78 to 6.93. Also, it has been obtained that the value of dielectric constant at 20% moisture is in between 11.03 to 11.17. It has been calculated the value of dielectric constant at 30% moisture, exhibits in between 16.69 to 16.98. The value of dielectric constant at 40% moisture has been estimated in between 26.1 to 26.7. Lastly it has been concluded that dielectric constant are very important parameter and panacea for progressive farmers.

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