Dependence of Dielectric Constant on Physiochemical Properties of soil samples of Northern Maharashtra

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ABSTRACT: Soil is one of the most consequential resources of the nature. All living things depend on plants, and plants grow in soil for day to day need. The principal and objective of the study was to ascertain the status of physiochemical properties like Water holding capacity, Organic Matter, Chloride, Calcium, Magnesium, Potassium, Phosphorus and some electrical properties are additionally studied from soil, these parameters have been analyzed with the avail of standard analytical methods and procedures presented systematically. The microwave conductivity, relaxation time, emissivity (e) and tangent loss of soil were withal calculated from the quantified value of intricate dielectric permittivity. Besides agricultural applications, such studies may find paramountcy in better understanding of soil physics and withal for analyzing the satellite data in remote sensing.

KEYWORDS: Soil composition, Role of Physico-chemical properties, Dielectric properties

INTRODUCTION

Irrigation plays an important role in the agriculture development. Crop production increases considerably if irrigation is provided to dry lands. Nashik district is well known for the grapes and onion production as well as export. Area under fruits and other cash crops show increase in recent time. One of the main reasons behind this cropping pattern change is the irrigation development in the district [1]. Soils are medium in which crop grows to food and cloth. Soil is not only important for agriculture but also have more useful for living organisms. Soil as a component of the terrestrial ecosystem fulfills many function including those that are essential for sustaining plant growth [2]. Soil is the most vital and precious natural resource that sustains life on the earth. Soil is one of the most significant ecological factors, on which plants depend for their nutrients, water and mineral supply. Soil, as most people think, is not a dead inert matter of minerals. But a healthy soil is indeed alive and dynamic consisting of microorganisms. The top-most layer of soil is comparatively richer in nutrients and supports maximum bio-farms. The profile character varies distinctly from place to place, particularly with respect to their depth, color and composition. The soil is a natural body of mineral and organic material differentiated into horizons [3]. Conventional agriculture has been largely dependent on intensive chemical inputs which play an important role in improving food productivity to meet human demands. In recent years, most of the farmers are using the excess amount of fertilizers and pesticides. Due to excess use of chemicals soil quality decreases. Small crop also affected due to large use of fertilizers and pesticides. So it becomes essential to analysis of soil parameter [4].

Soil formation is a constructive as well as destructive process [5]. Soil is composed of particles of broken rock that have been altered by chemical and mechanical processes that weathering and erosion. Soil has a complex function which is beneficial to human and other living organism [3]. Soil is not merely a group of mineral particles. It has also a biological system of living organism as well as some other components. The climate and other factor largely affect the soil formation. The mineral composition of soil, the organic matter within it and the environment, all are determined by the chemical properties of soil [6]. It also of variable depth, which differs from the parent material below in morphology, physical properties and constitution, chemical properties and composition and biological characteristics [7]. Chemistry of soil covers chemical reaction process in the soil pertaining to plant and animal growth and human development [8].

Different factors create different type of soil. The properties of soil along with its type have a great importance in agriculture [9]. Soil physico chemical properties deteriorates to the change in land use especially from agriculture and forest [6]. The change in physico chemical properties of soil leads to infertile or barren soil that does not support normal growth of vegetation for years [10]. Soil fertility is an important factor, which determine the growth of plant. It is depends on the concentration of N,P,K organic and inorganic materials, micronutrients and water. In general soil chemical fertility and in particular lack of nutrient inputs is a major factor in soil degradation [11]. Soil farming factors intraction results into the properties of soil. Physico chemical characteristics of different soils vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables [12]. For the high crop yield the farmers used the pesticides and fertilizers in excess amount causes serious environmental problems and also consider their possible impact on soil health. Nitrogen, phosphorus and potassium ratio is an important indicator in crop production that identifies balanced and unbalanced fertilization. Hence, balanced fertilizer application are important for high crop yield [13]. The food productivity and environmental quality is dependent on the physico-chemical properties of soil, so it is very important to know the basic knowledge about the physico-chemical properties of soil. A soil aggregate status usually deteriorates rapidly if soil is repeatedly cropped with annuals that supply little organic matter to the soil, require extensive cultivation and provide minimal vegetative cover [14]. There are various ways of addition and losses of nutrients as take place in soil. These nutrient cycling make the balance of organic and inorganic soil constituents. In recent years organic and inorganic fertilizers and pesticides are being widely used by farmers in agriculture to increase the yield and production of cultivable plants.

Importance of Physico-Chemical Properties in Soil Quality:

Texture

Soil having different textural groups, on basis of the proportion of different sized particles. Soil texture directly influences soil-water relation, aeration and root penetration. It also affect on the nutritional status of soil. Soil texture can be expressed significantly by its electrical conductivity. Clay textured soil is highly conductive while sandy soil are poor conductors [15].Soil texture also affects the nutrient supply of the soil [16]. Sandy soils are light soils having low nutrient concentration, low in ability to retain moisture, low in cation exchange capacity and buffer capacity, and rapidly permeable. The main problems to deal with sandy textured soil are maintaining moisture retention capacity and nutrient deficiency [17]. Sandy soil contains low organic matter. Al-Omran reported that sandy textured soil increased the squash crop productivity by addition of clay deposits [18]. Clayey soils are unsuitable for crops that do not tolerate prolonged soil wetness; they have low permeability and this constraint causes them to remain wet for a longer period than soils of lighter texture [19]. Clay contains high organic matter. It can resist water and wind erosion of the soil better. Clay content has high cation exchange capacity and pH buffering capacity [20].

pH

pH is a most important physical properties of soil. It is having great effects on solute concentration and absorption in soil [21]. Soil pH is an important consideration for farmers and gardeners for several reasons, including the fact that many plants and soil life forms prefer either alkaline or acidic condition [22]. If the pH is less than 6 then it is said to be a acidic soil, the pH range from 6-8.5 it's a normal soil and greater than 8.5 then it is said to be alkaline soil. pH is an important parameter as it help in ensuring availability of plants nutrients e.g. Fe, Mn, Zn and Cu are more available in acidic than alkaline soils [23]. It also helps in maintaining the soil fertility and to quantify the amendments used for amelioration [24]. pH is a good sign to maintain equilibrium between nutrients in soil. It is also an indicator of plant and other living organism, available nutrients, cation exchange capacity and organic matter content [25]. Williams, has studied effect of pH on nutrient balance and observed that high pH of soil can affect the micronutrients content present in soil [26].

Electrical Conductivity.

Electrical conductivity varies with depth and its range of variation was less in upland profile, probably occurred due to slope of land surface, high permeability and high rainfall, responsible to leach out alkali and alkaline bases [27]. Electrical conductivity is a very quick, simple and inexpensive method to check health of soils. It is a measure of ions present in solution. The electrical conductivity of a soil solution increases with the increased concentration of ions .It is a measurement that correlate with soil properties that affect soil texture, cation exchange capacity, drainage condition, organic matter level, salinity and subsoil characteristics [28].

Organic matter

Soil organic matter supplies essential nutrients and has unexcelled capacity to hold water and absorb cation. It also functions as a source of food for soil microbes and thereby helps enhance and control their activity. Micronutrient plays a vital role in maintaining soil health and also productivity of crops The content of organic matter in a soil can be maintained the structure of soil. It affects the available water capacity and infiltration rate. It is a source of nitrogen and other essential nutrients for crops that's why it enhances the usefulness of soil for agricultural purposes. The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soils. Soils with finer particles and with higher organic matter can generally provide a greater reserve of these elements whereas, coarse textured soils such as, sand have fewer reserves and tend to get depleted rather quickly

Nitrogen

Nitrogen is a most important fertilizer element. It is the most important major nutrient required by plant for proper growth and development and it is a part of all living cells is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy [29].

Phosphorus

Phosphorus is a part of every living cell in plant. It is one of the most important micronutrient essential for plant growth. Phosphorus is most often limiting nutrients remains present in plant nuclei and act as a energy storage. It helps in transfer of energy [30]. Phosphorus is an essential element because of the large amount of phosphorus required by plants growth. It is also an essential part of the process of photosynthesis, involved in the formation of all oils, sugars, starches, etc. [31].

Potassium

Potassium is not an integral part of any major plant component but it plays a key role in a vast array of physiological process vital to plant growth from protein synthesis to maintenance of plant water balance [6]. It is involved in many plant metabolism reactions, ranging from lignin and cellulose used for formation of cellular structural components, to regulation of photosynthesis and production of plant sugars that are used for various plant metabolic need.

MATERIALS AND METHODS

Study Area

The fertile soil of Dindori is one of the best for producing optimum quality grapes for wine. The soil quality is of lateritic type and has tiny gravel in it to make it well drained. The gravel assists the roots of the vines to go deeper into the soil and reach the micronutrients embedded deeper in the rich soil.

Nashik District is a major agricultural center known for grapes, onion, flowers, sugar cane, rice and popular vegetables. Grapes, onions and flowers are exported all over the World. Cultivated area is around 56% of the total land area. Nashik is situated 2,000 feet above sea level in the Western Ghats of India. Located in northern Maharashtra - approximately 200 km from Mumbai and Pune - it is an important industrial and

agricultural area. The climate of the area is mild throughout the year, ranging from winter lows of 8-10°C to summer highs of 32-35°C. The Nashik region consists of two rainfall zones. The first is the high rainfall (80-100 cm) hilly Konkan area in the west, and the second is the low rainfall fertile plain to the east.

Sample Preparation

Soil samples were collected in the depth of 0-20cm from 10 sites from Dindori tehsil of Nasik District. Soil samples were completely air dried and passed through 2mm sieve and stored in properly labeled cloth bags as per the standard procedures. Quartering technique was used for the preparation of soil samples. The sieved out particles are then oven dried to a temperature around 110^{o} C in order to completely remove any trace of moisture.

Dielectric Measurements

In the present study, Two Point Method has been used to measure the complex dielectric constant of soils. The wave guide cell method is used to determine dielectric constant of these soil samples. The X-band microwave bench is setup in TE_{10} mode with Reflex Klystron source operating at frequencies 9.56 GHz is used for this purpose. The dielectric cell shorted with matched load is connected at load end. The reflected wave combined with incidental wave to give standing wave patterns. These standing wave patterns used to determine the values of shift in minima resulted due to before and after inserting the sample. The Dielectric constant (ϵ') is determined.

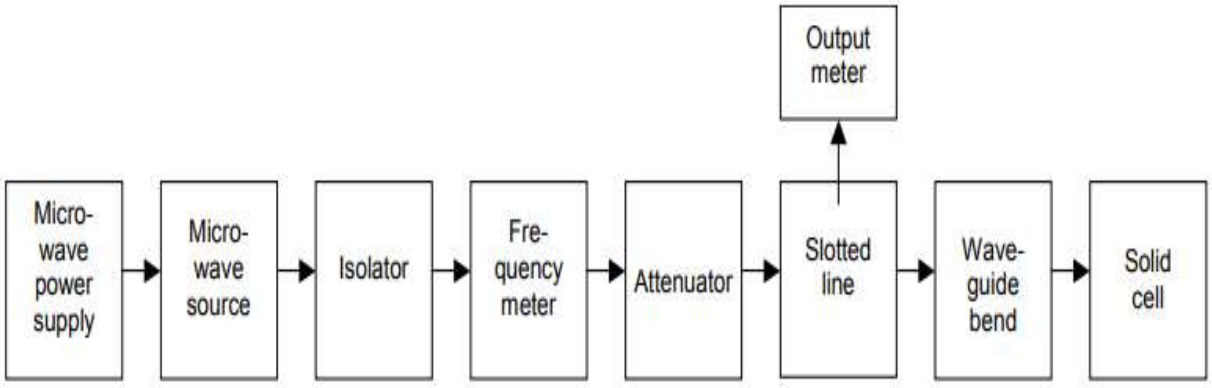


FIG. 1. Experimental set-up of microwave X-band waveguide transmission line.

RESULTS AND DISCUSSIONS

The study of different physico-chemical characteristic of the soil sample from different location of nearby village sites of Dindori Taluka which is mentioned below. The texture, physical and chemical properties of the samples under study are reported in Tables 1a and 1 b. These samples are a mixture of sand, silt and clay with a very high percentage of clay. The average pH of the soil from selected sites recorded in between 6.93 – 7.68. Organic carbon content ranges from 0.51%to 1.25%, the available nitrogen was recorded in the ranges from 79 to 169 kg/ha, available Potassium in the soil ranges from 205 to 342 kg/ha and available Phosphorus ranges from 43.8 to 138.05 kg/ha.

Jawar, wheat and gram are grown in the Dindori during Rabi season. Jawar is common in this taluka. However, in Dindori it is grown on a large scale. Ten representative villages were chosen and different number of surface soil samples (0-20cm) collected and analyzed for physico-

chemical properties and available N, P, K, status. Results revealed that texture of the soils varied from clay loam to clay. Soil samples were found high in organic carbon. The soils were low to moderate in available nitrogen content, very low in available phosphorous content while, the available potassium indicates very high content. Significant positive correlations were found to exist between organic carbon and available N, P, K status of soil under study. Soil characterization in relation to evaluation of fertility status of the vineyard soils is valuable in context of sustainable agricultural production. Nitrogen, Phosphorous and Potassium are important soil elements that control its fertility and yields of the crops. The physicochemical analysis of soil is very useful in order to plan fertilization and to know the residues of fertilizers in relation to the crop, tillage and climate. An analysis can highlight shortages and help to understanding of the cause of an abnormal growth

Table No.1a Chemical characterization of soil samples of Dindori Tehsil

Sample No.	pH	Electric conductivity	Organic Carbon	Calcium Carbonate	Avai. Nitrogen	Avai. Phosphorus	Avai. Potassium	Iron	Manganese	Zinc	Copper
1	7.68	0.29	0.51	4.25	158	72.63	269	1.82	11.5	0.31	2.99
2	7.5	0.33	0.74	0.25	147	108.67	342	3.93	10.67	8.04	4.8
3	7.61	0.42	0.85	12.25	169	43.8	250	0.42	5.91	0.64	4.87
4	7.64	0.39	0.67	4.75	79	44.35	273	2.44	10.47	0	3.31
5	7.17	0.5	0.55	0.75	102	138.05	246	4.03	10.78	1.19	4.27
6	6.93	0.44	0.75	0.5	135	77.65	205	11.56	10.5	7.88	13.83
7	7.59	0.31	0.96	14.25	113	50.45	217	1.15	8.81	5.3	9.37
8	7.64	0.37	0.71	3.25	124	69.58	227	1.49	9.82	6.25	11.37
9	7.51	0.29	0.62	1.25	147	71.52	254	7.03	10.37	1.19	3.32
10	7.2	0.43	1.25	0.25	169	74.29	262	9.11	10.16	9.28	8.55

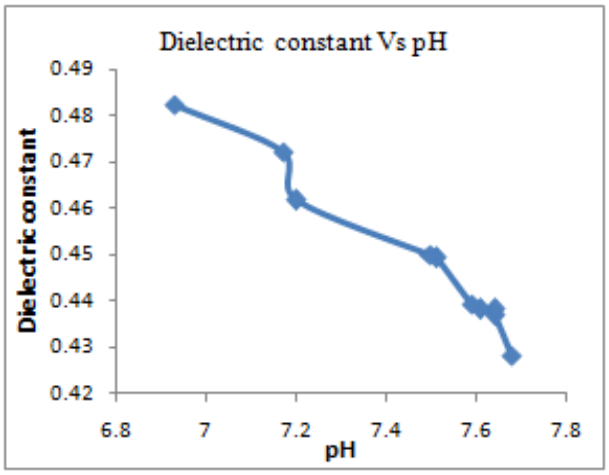
Table No.1b Physical characterization of soil samples of Dindori Tehsil

Physical characterization of soil samples of Dindori Tahsil

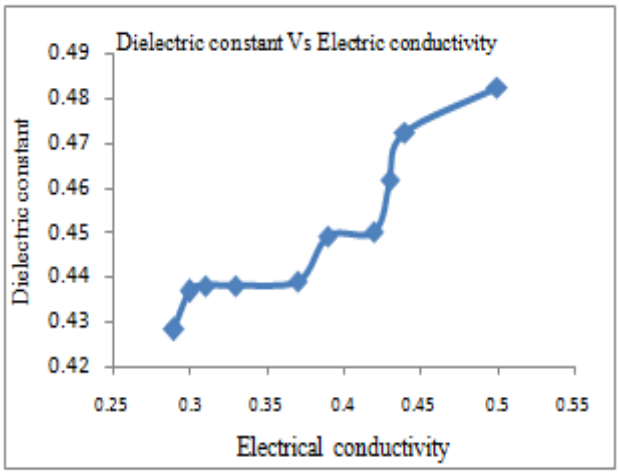
Sample No.	Bulk Density (gmcm-1)	Particle Density (gmcm-1)	Water holding capacity (%)	Hydraulic conductivity (cm/hr)	Sand (%)	Silt (%)	Clay (%)	Textural Class
1	1.23	2.49	41	5.36 Moderate	87.25	4	8.48	Loamy Sand
2	1.21	2.63	41	4.94 Moderate	82.37	5.7	11.93	Loamy Sand
3	1.36	2.35	46	3.95 Moderate	63.4	28.85	7.75	Sandy Loam
4	1.17	2.44	48	2.96 Moderate	41.75	35	22.5	Loam
5	1.12	2.22	49	2.96 Moderate	38.42	45.15	16.43	Loam
6	1.22	2.54	46	1.83 Moderate slow	30.35	38.55	31.1	Clay Loam
7	1.18	2.2	59	3.39 Moderate	41.27	43.68	15.05	Loam
8	1.22	2.34	56	1.55 Moderate slow	36.75	17.92	44.53	Clay
9	1.28	2.34	47	1.97 Moderate slow	31.55	40.97	27.48	Clay Loam
10	1.23	2.33	56	1.41 Moderate slow	26.35	26.17	47.48	Clay

Organic matter in soil significantly affects the dielectric properties of soil. Most of the crops generally grow best if pH is close to neutral (pH= 6 to 7.5) although a few crops prefer acid or alkaline soils. The nutrition, growth, and yields for most of the crops decrease when pH is low and increase as pH rises to an optimum level. Graph 1 gives the relation between pH and dielectric constant.

Our experimental results are found to agree with the theoretical models developed by many investigators working in this field [32-34]. These models also give a strong linear relationship between dielectric constant and electrical conductivity of the soils similar to graph 2.

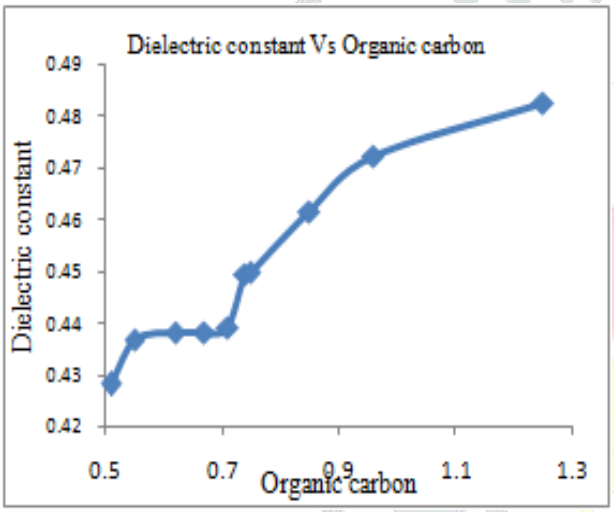


Graph 1 Dielectric constant Vs pH

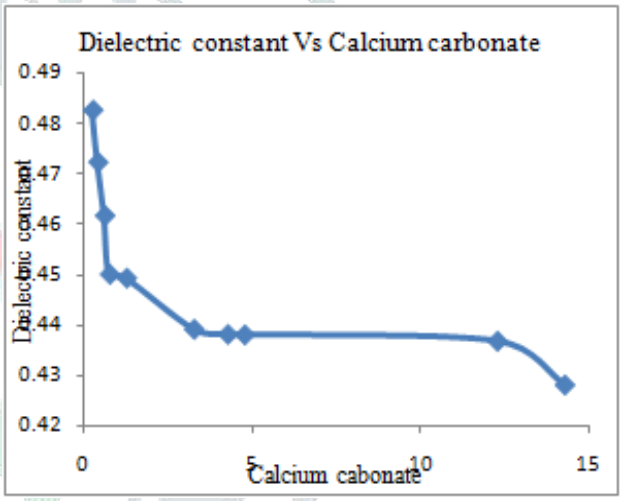


Graph 2 Dielectric constant Vs Electric Conductivity

Graph 3 shows the variation dielectric constant with organic carbon and graph 4 gives the variation of dielectric constant with CaCO3 of soil samples. It further show a positive significant correlation of dielectric constant with organic carbon content and negative significant correlation with CaCO3 content for soil samples.

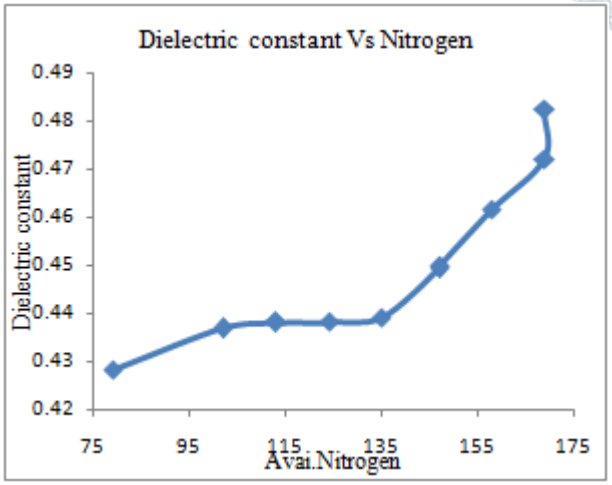


Graph 3 Dielectric constant Vs Organic carbon

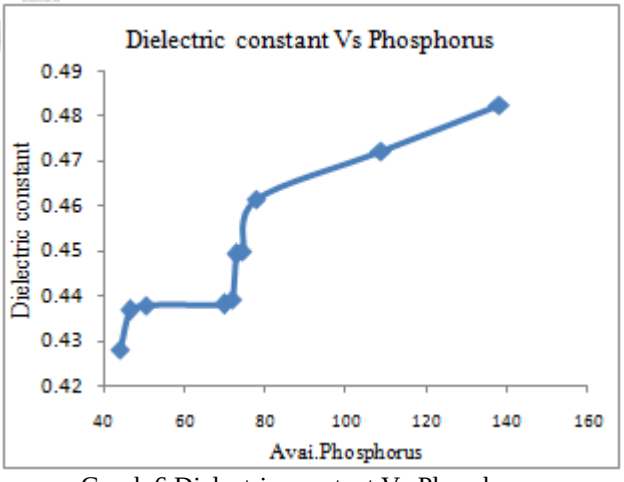


Graph 4 Dielectric constant Vs Calcium cabonate

Graph 5,6,7 show strong Positive correlations of dielectric constant of soil samples with available nitrogen, phosphorus, potassium content. Thus, the correlations between dielectric constant and available macronutrients in the soils are stronger. Our results discussed here also show good agreement with the results of earlier investigators on soil characteristics [35].



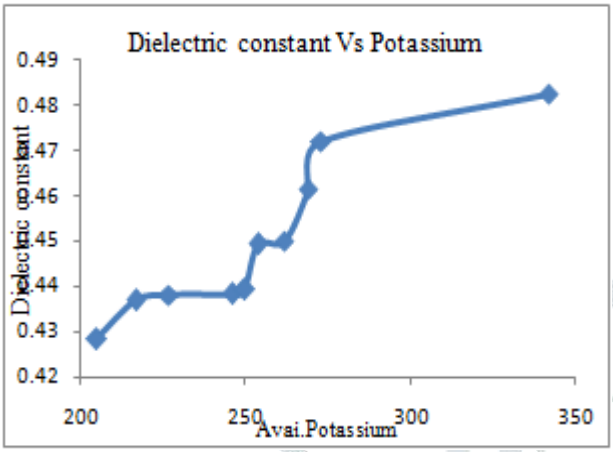
Graph 5 Dielectric constant Vs Nitrogen



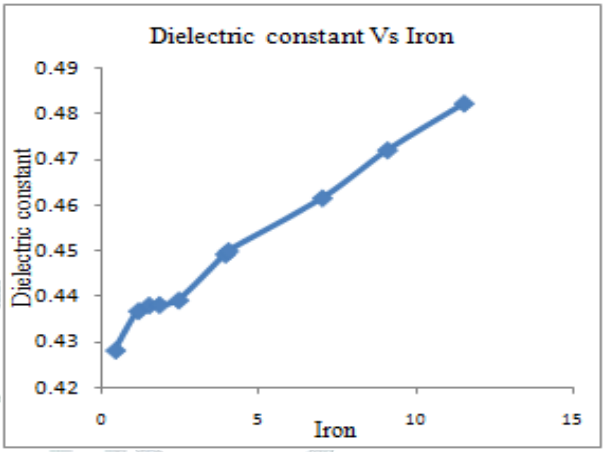
Graph 6 Dielectric constant Vs Phosphorus

The availability of plant nutrients is influenced by the amount of carbonates in the soil. This is due to the effect of carbonates on soil pH and also on nutrient availability.

Graph 7 and 8 shows positive correlation of dielectric constant with potassium and iron. Studies reported here have lot of importance not only for better understanding of soil physics but also in remote sensing applications. Especially, by knowing the correlation coefficient of various soil properties and nutrients with dielectric constant help to understand and analyze the satellite data. The present work thus, will be helpful for the prediction of the soil texture, nutrients type and their concentrations present in the soils from the knowledge of electrical conductivity and dielectric constant.

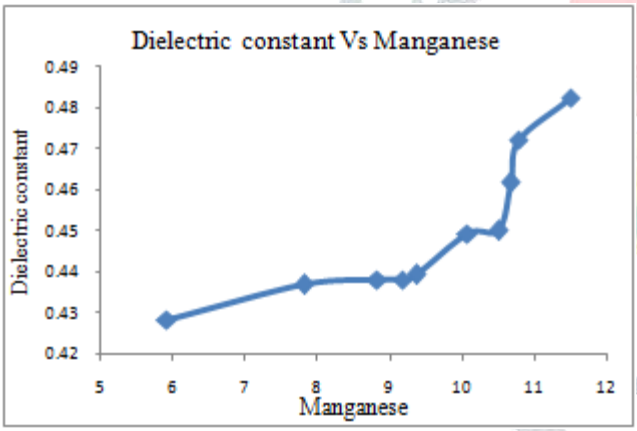


Graph 7 Dielectric constant Vs Potassium

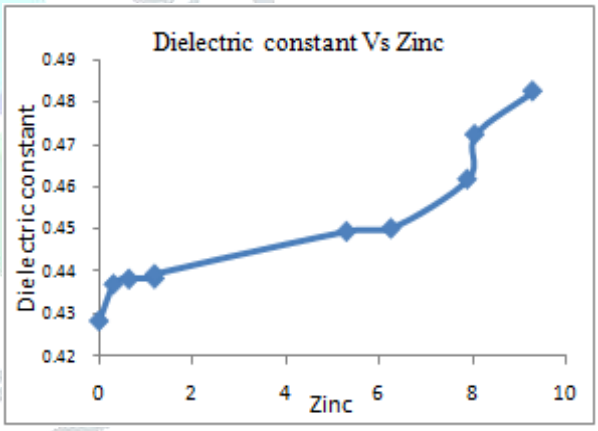


Graph 8 Dielectric constant Vs Iron

Graph 9 and 10 shows positive correlation of dielectric constant with Manganese and Zinc. Studies reported available manganese ranges from 5.91 to 11.5 ppm and available zinc ranges from 0.0 to 9.28 ppm, available copper ranges from 2.99 to 13.83 ppm.

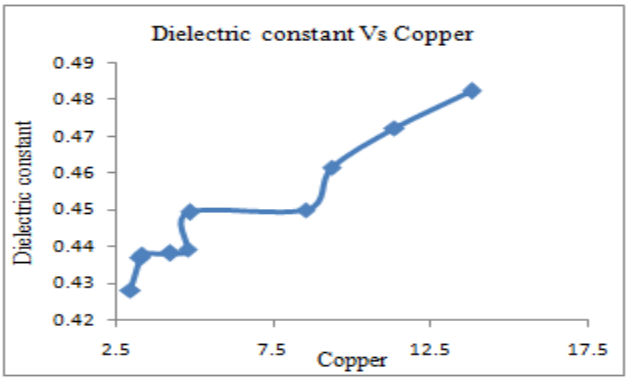


Graph 9 Dielectric constant Vs Manganese



Graph 10 Dielectric constant Vs Zinc

Organic matter is an important source of nutrients for plants. Nitrogen, phosphorus and sulphur are considered macronutrients; essential micronutrients are iron, manganese, zinc, copper, boron and chlorine. Due to dependence of dielectric constant on the physical constituents and chemical composition of the soil, the study of its variability with physical constituents and chemical composition is required .Graph 11 gives the relation between dielectric constant and Copper.



Graph 11 Dielectric constant Vs Copper

CONCLUSION:

Colour of soil of Dindori tehsil is black. Soil of Dindori is good for great production of grapes. Soil texture has remarkable effect on the dielectric properties. Study of physical properties, chemical properties, dielectric properties of soils with varied organic and inorganic matter is utilizable in agriculture to prognosticate quality and fertility of soil. Additionally it is subsidiary for the researchers working in the field of microwave remote sensing. The results from such studies are paramount to understand the fundamental nature of the replication of particular soil to high frequency electromagnetic field.

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