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Estimation of Soil Density, Porosity, Water Holding Capacity, and Moisture content of Arpa River Based Soil

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Abstract

Soil physics plays a pivotal role in the present scenario. It is directly related to the economic growth of India. An attempt has been made in this paper to research as well as estimate some important physical properties of the Arpa River-based soil of Bilaspur, Chhattisgarh. For soil analysis, it is required to calculate different Chemical, Physical, and Electrical properties, and Geographical. The physical properties of soil are influenced by the size, arrangement, composition, and properties of soil particles. Six distinct soil samples are taken for the current study from different places in the Arpa River. Many physical properties of these six soil samples are examined, including bulk density, particle density, porosity, water holding capacity, soil moisture content, and so on. which can be determined by different standard methods and mathematical formulas. The bulk density in this study ranges from 1.1332 to 1.466 g/cm3. The range of particle density is 2.0449 to 2.5252 g/cm3. After the determination of Bulk density and particle density, the percentage of solid space and pore space (Porosity) was evaluated. Water holding capacity varies from 8% to 48%. The moisture content of six samples varies from 25.92% to 48.14%. Based on physico-chemical parameters it is easy to find the type and amount of fertilizers for particular crops.

Keywords: *Soil Physics, Physico-Chemical Properties, Fertilizers, Arpa River*

1. Introduction

The soil has the most effective association between the biosphere and lithosphere, The soil plays a vital role in the environment and agriculture, and it is a natural resource that is essentially non-renewable. (Moraeties et al., 2016). The presence of fertilizers and micronutrients influences crop yield and quality. Because soil is a universal medium for plant growth, its condition is critical. Soil provides essential nutrients to the plant (Narkhede et al., 2011). There is a mutual relationship between soil and agriculture. Nutrient deficiency has become a major constraint to soil productivity, sustainability, and stability (Bell R.W. and Dell B.,2008). In soil analysis, physical, chemical, electrical, and geographical properties are very important. In physical properties texture, particle density, water holding capacity, porosity, wilting point, transition moisture, bulk density, moisture content, hydraulic conductivity, field capacity, and color are very important. In chemical properties pH value, electrical conductivity, organic carbon, micronutrients, and macronutrients are widely analyzed. Electrical properties cover dielectric constant, dielectric loss, tangent loss, conductivity, relaxation time, and emissivity. Geographical parameters cover latitude, altitude, longitude, and average rainfall. One of the most valuable natural resources in a nation is its soil, and creating plans for its optimal use that will maximize agricultural output requires a thorough understanding of its properties. (Kumar P. et al., 2013). It is essential to regularly assess the nutrient status of the soil to identify any toxicities or nutrient deficits that may impair crop growth (Memon et al., 2010). Soil physicochemical changes result in infertile or arid land that cannot maintain regular vegetation expansion over time (Jha and Singh, 1991). Therefore, research into the physical-chemical characteristics of soil is crucial for both agricultural and environmental reasons.

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2. Material and Methodology

Samples of soil were collected from several sites along the Arpa River in Bilaspur, Chhattisgarh. Arpa originated from Khondari-Khongsara, at Pendra (Gouerla-Pendra-Marwahi District), and meets the Mahanadi River close to Bartori, where it flows to meet the Seonath River. Arpa is approximately 147 kilometers long, with an average water flow of 400 meters. Arpa is approximately 147 kilometers long, with a typical flow of water of 400 meters. The area covered by the river is 2022 square kilometers. The research locations are different places (from the beginning to the meeting point) of Apra River places. There are 6 sample sites which are Pendra Road (Gouerla-Pendra-Marwahi (GPM) District, Sendri, Indra-Setu, Chhatghat, Darrighat, Bartori (Bilaspur). After collecting the samples, the soil is dried and crushed. Now the sieving process is followed to gain a fine powder form of soil sample and remove the bigger dirt particles from the soil. Next, to eliminate any remaining moisture, the sieved particles are dried in a hot air oven for 24 hours at a temperature of about 110oC. The sample has been renamed MUT (Material Under Testing).

2.1 Soil density

Density is defined as the weight of a substance per unit volume. It is expressed as gram per cubic centimeter (gm/cm3). Soil mass is made up of small soil particles together with a certain amount of free or empty space. The space of soil is known as pore space. In soil, there are two common density measurements: Particle density and Bulk density. The definition of bulk density is the mass per unit volume of dry soil. Bulk density is also called “Apparent specific gravity”. For normal soil bulk density varies from 1.0-1.65 mg/m3. Very compact soil goes up to 2.0 mg/m3. Bulk density is determined by the Black (1965) Method. The formula for the calculation of Bulk density is as follows;

$$Y = \frac{\text{Oven dry weight of soil}}{\text{Volume od soil}} \quad \text{---------------(1)}$$

Particle density is another term for particle density. It is the weight of the solid portion divided by its volume. It is measured in g/cm3 and represents the relationship between the total mass of soil solids (Ms) and the total volume of soil solids (Vs). In many mineral soils, particle density varies between 2.60-2.70 mg / m3. The particle density decreases due to the presence of organic matter but is higher due to the presence of heavy minerals such as magnetite, zircon, etc. Particle density is determined by Black (1965) method.

2.2 Porosity

Pore space is also called void space. It is the void portion of soil that is not occupied by any solid material. Soil porosity is a very important concept of soil property and it is defined as the volumetric percentage of total pore space in soil. These pore spaces are occupied by air and water. The formula for the calculation of the Percentage of solid space and pore space is given below.

$$\%\ \text{Solid space} = \frac{Bulk\ density}{particle\ density} \text{ X } 100 \text{ ----------(2)}$$

$$\%\ \text{Pore space (Porosity)} = 100 - (\%\ \text{Solid space}) \text{ --------(3)}$$

2.3 Soil texture

The soil texture is determined by the proportion of clay, sand, and silt. The texture of the soil is an important soil characteristic because it determines intake rates, the amount of aeration, the ease of tilting the soil, and water storage in the soil and it will influence soil fertility (Shrivastava S.K. and Mishra G.P., 2004). Clay texture soil is highly conductive as sandy soil is a very poor conductor (Marx E.S. *et al.*, 1999). Many other soil functions and soil erosion can be influenced by variations in soil texture, both directly and indirectly (Adhikari K. *et al.*, 2009). The international pipette method and bouyoucos hydrometer method are widely used for the determination of texture. In the present work, the international pipette method has been used. This method is based on the principle of sedimentation.

2.4 Moisture Content (MC)

Soils typically contain a limited amount of water, which is known as the "soil moisture content." The pore spaces between soil aggregates contain this moisture. This pore space is occupied by water or air. The soil is completely dry if there is air in every pore. The soil is said to be saturated when all of its water is present in the pores. The water content of the soil is influenced by its composition and feel. The moisture level in soil and vegetation can be measured and monitored by microwave remote sensing (Lakhankar T. et al.,2009). The soil moisture mainly depends on groundwater conditions, organic matter, clay minerals, void ratio, and particle size (Yennawar V.B. et al., 2013). Moisture content is determined by the Gravimetric/oven-dry method.

2.5 Water Holding Capacity (WHC)

One crucial factor in assessing the health of the soil is its ability to hold water. A good water-holding capacity indicates that the soil is in good physical condition (Soffe R.E., 1995). To develop a regional soil water balance, it is essential to comprehend the soil's capacity to hold water (Vanderlinden K. et al., 2005). Water stress may inhibit plant growth if water is scarce. Growth, on the other hand, may be limited by insufficient aeration if air is limited by too much water (Gadani D., 2010). There is a distinction between soil moisture content and water retention capacity. While water-holding capacity is a fixed standard value that is inherent to soil, soil moisture content is the amount of moisture held at the time of sampling by the soil. Sample location and time affect the amount of moisture in the soil (Tayade, A.,2021).

3. Result and Discussion

This study helps in determining the important physical parameters and their effect on the soil quality of Arpa River-based soil. The obtained values of, Particle density solid space (%), pore space (%), and Bulk density of all samples are presented in Table 1. Table 2 represents the obtained values of Water Holding Capacity (WHC %), Moisture Content W (%), Sand (%), Silt (%), and Clay (%) in all samples.

Table .1 Bulk density, Particle density, and solid and pore space of soil samples

Sample No.	Location of Sample	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	% Solid space	% Pore space
Sample 1	Pendra road	1.1332	2.0833	54.3944	45.6056
Sample 2	Sedari	1.4152	2.257	62.7027	37.2972
Sample 3	Indra -setu	1.2404	2.4038	51.6016	48.3983
Sample 4	Chhatghat	1.2872	2.336	55.1027	44.8973
Sample 5	Darrighat	1.466	2.5252	58.0548	41.9452
Sample 6	Bartori	1.1744	2.0449	57.4282	42.5718

Table .2 Water Holding Capacity (%), Moisture-Content (%), Sand (%), Silt (%), Clay (%)

Sample No.	Location of Sample	Water Holding Capacity of Soil (%)	Moisture Content W (%)	Sand (%)	Silt (%)	Clay (%)
Sample 1	Pendra road	36	28.57	48.5	23.32	28.18
Sample 2	Sedari	24	30.30	59.3	15.24	25.46
Sample 3	Indra -setu	4	48.14	89.9	4.92	5.18
Sample 4	Chhatghat	16	31.81	69.98	14.36	15.66
Sample 5	Darrighat	8	25.92	83.26	6.34	10.4
Sample 6	Bartori	48	47.62	55.8	13.78	30.42

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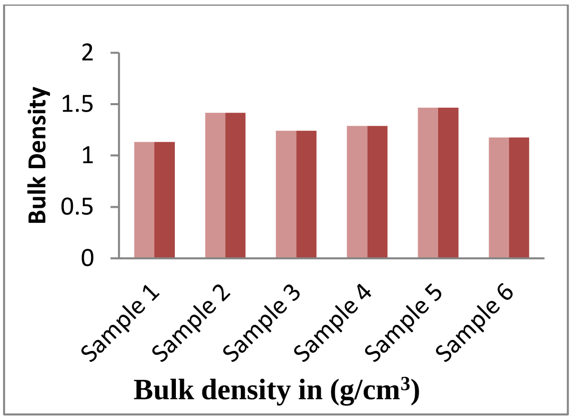

Fig 1. Graphical representation of Bulk density

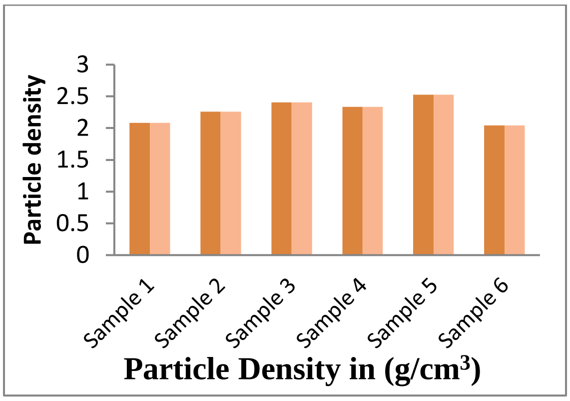

Fig 2. Graphical representation of Particle density

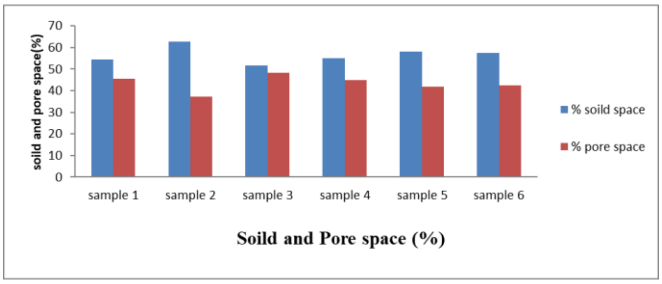

Fig 3. Graphical representation of solid space and pore space in percentage

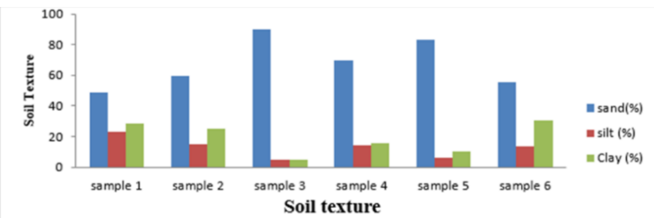

Fig 4. Graphical representation of Soil Texture

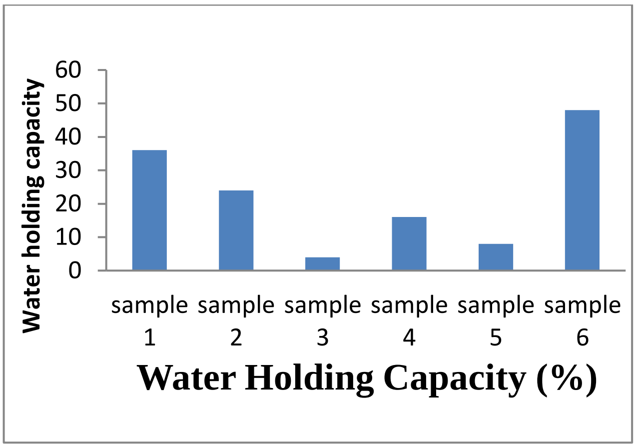

Fig 5. Graphical representation of WHC (%)

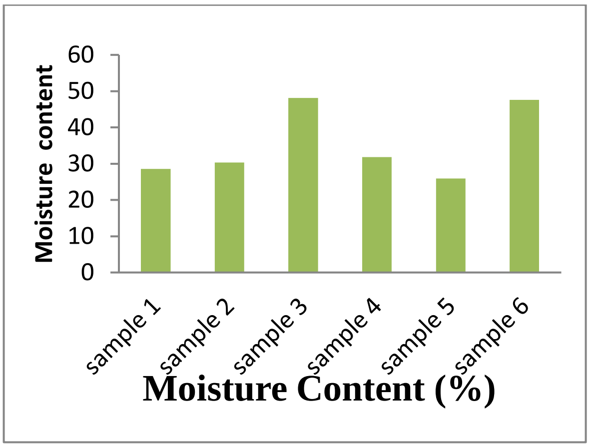

Fig 6. Graphical presentation of Moisture Content

Fig. 1 represents the bulk density of samples. Bulk density describes the level of compaction of soil. It is the amount of soil in a given volume. The bulk density in this study ranges from 1.1332 to 1.466 g/cm3. It is clear from the graph that bulk density in sample five is maximum whereas it is minimum in sample one.

Fig. 2 represents particle density. Particle density varies from 2.0449 to 2.5252 g/cm3. The particle density of sample five is maximum whereas it is minimum in sample six.

Fig. 3 represents the Percentage of pore space and solid space. Pore space is maximum in sample three while solid space percentage is maximum in sample two.

Fig. 4 represents the soil texture. This figure represents the percentage of sand, silt, and clay, it is mentioned that sample three is sandy which has the highest sand content, silt content is maximum in sample one and clay content is maximum in sample six.

Fig. 5 represents the percentage of water-holding capacity of samples. Water holding capacity varies from 4% to 48%. WHC is maximum in sample six while minimum in sample three.

Fig. 6 represents the percentage of soil moisture content. The soil moisture content varies from 25.92% to 48.14%. It is highest in sample three while sample five has low moisture content.

4. Conclusion

The study of the physical properties of Arpa-based soil is useful in horticulture, agriculture, and other remote sensing applications. The results obtained after investigation are useful to understand the behavior of river-based soil and to improve the fertility of soil**.** The knowledge of soil texture plays a pivotal role in plant growth. The textures of the various horizons in a soil profile are usually different. Up to a certain point, the subsoil should contain more clay because this can increase the amount of water and nutrients that are stored there. The texture of the soil influences the type of crop that can be grown on a plot of land. Soil texture tells a farmer what type of soil is present on his farm. Soil texture also affects the relative amounts of water and air in the soil. When proper fertilizers are added to soil, pore space increases which is directly related to particle density and bulk density.

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