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Research Article

Soil Chemical Properties and Available Macronutrients in Silt Clay Loam and Sandy Clay Loam Soil

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Abstract

A survey of chemical properties of soil of farmers of 'Bastar' an allied area of Chhattisgarh was carried out in 2014-15. The main objectives of this study was to collect information regarding soil macronutrient status and its relation to various chemical properties of soil, for this 6 sampling points were selected. Soil samples were collected at a depth of 0-15 and 15-30 cm and analyzed Nitrogen (N), phosphorous (P), potassium (K). The N, P, K, ranged from 188.6-276.64, 7.62-10.72, 121-242.5, kg ha^{-1} respectively. By analyzing the Soil Sample, it was found to be slightly acidic. The nitrogen, phosphorous, potassium values are found to be low in all villages. There is an increasing awareness of the need to pay greater attention in the role of macronutrient enhancement in the soil for good soil health and proper nutrition of plant so as to attain optimum economic yield.

Keywords: Bastar district, chemical properties, physical properties, soil

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Introduction

"The thin layer of soil covering the earth's surface represents the difference between survival extinction for most terrestrial life." (John W. Doran and Timothy B. Parkin). Soil is the biologically active, structured porous medium that has developed below the continental land surface on our planet. Soils represent one of the most complex and dynamic natural systems studied by scientists. Knowledge of their chemical, physical and biological properties is a pre requisite for sustaining productivity of the land. The communication of soil knowledge is therefore no easy task. The fundamental components of soil are minerals, organic matter, water and air. Mineral particles are inorganic materials derived from rocks and are extremely variable in size. The weathering of minerals affects the composition of the soil solution because it can contain plant nutrients as well as toxic substances. The rate of weathering is affected by the size and composition of minerals, soil pH, temperature, biotic activity, water and air content.

Nitrogen is important for growth because it is a major part of all amino acids, which are the building blocks of all proteins, including the enzymes, which control virtually all biological processes. A good supply of nitrogen stimulates root growth and development, as well as the uptake of other nutrients. Plants deficient in nitrogen tend to have a pale yellowish green color (chlorosis), have a stunted appearance, and develop thin, spindly stems [7].

Much of the nitrogen reserve is stored in the soil as organic matter and most of this organic fraction is found in the upper soil horizons. At surface mines, the upper soil horizons are usually removed and stockpiled prior to disturbance. The storage of topsoil allows for relatively rapid conversion of organic nitrogen to soluble nitrate (NO3-) and is subject to leaching or conversion to nitrogen gas (denitrification) which volatilizes out of solution into the atmosphere. Thus, when stored topsoil is spread on a disturbed landscape, nitrogen reserves may be depleted or altered by several chemical and biological phenomena and the healthy cycling of nitrogen through the ecosystem inhibited or prevented [15].

Phosphorous enhances many aspects of plant physiology, including the fundamental processes of photosynthesis, nitrogen fixation, flowering, fruiting (including seed production), and maturation. Root growth, particularly development of lateral roots and fibrous rootlets, is encouraged by phosphorous. Phosphorous uptake by plants is about one-tenth that of nitrogen and one-twentieth that of potassium. Its deficiency is generally not as easy to recognize in plants as are deficiencies in many other nutrients. A phosphorous-deficient plant is usually stunted, thin-stemmed, and spindly, but its foliage is often dark, almost bluish, green. Thus, unless much larger, healthy plants are present to make a comparison, phosphorous-deficient plants often seem quite normal in appearance. In severe cases, phosphorous deficiency can cause yellowing and senescence of leaves [7]. Phosphorous is usually plant-available in soil as inorganic phosphate ions (HPO42- and H2PO42-) and sometimes as soluble organic phosphorous. The HPO42- anion dominates in strongly acidic soils while the H2PO4- anion dominates in alkaline soils. Both anions are important in near-neutral soils. The major portion of the total soil phosphorous - 96% to 99% - is not plant-available. The bulk of the soil phosphorous exists in three general groups of compounds - namely, organic phosphorous, calcium-bound inorganic phosphorous, and iron- or aluminum-bound inorganic phosphorous. Most of these phosphorous groups have very low solubility and are not readily available for plant uptake.

Of all the essential elements, potassium is the third most likely, after nitrogen and phosphorous, to limit plant productivity. For this reason, it is commonly applied to soils as fertilizer and is a component of most mixed fertilizers. Potassium is known to activate 80 different enzymes responsible for such plant and animal processes as energy metabolism, starch synthesis, nitrate reduction, photosynthesis, and sugar degradation. Potassium plays a critical role in reducing the loss of water from leaves and increases the ability of the roots to take up water from the soil. It also helps plants adapt to environmental stresses. Good potassium nutrition is linked to improved drought tolerance, improved winter hardiness, better resistance to certain fungal diseases, and greater tolerance to insect pests. Potassium deficiency is relatively easy to detect compared to deficiencies in phosphorous. The tips and edges of the oldest leaves begin to yellow (chlorosis) and die (necrosis), so that the leaves appear to have been burned on the edges [7].

The original sources of potassium are the primary minerals, such as micas (biotite and muscovite) and potassium feldspar (orthoclase and microcline). As these minerals weather, the potassium becomes more available as readily exchangeable and soluble potassium which can be adsorbed by plants roots. At any one time, most soil potassium is in primary minerals and nonexchangeable forms. In relatively fertile soils, the release of potassium from these forms to the exchangeable and soil solution forms that plants can use directly, may be sufficiently rapid to keep plants supplied with enough potassium for optimum growth. Conversely, in relatively nonfertile soils, the levels of exchangeable and solution potassium may have to be supplemented by outside sources, such as chemical fertilizers, poultry manure, or wood ashes. Without these additions, the supply of available potassium will likely be depleted over a period of years and the productivity of the soil will likewise decline [7].

India is a country where more than 60% of the population depends on agriculture, and soil is the major factor that affects the crop growth. Chhattisgarh is situated in the central part of India. Bastar Plateau is the southern part of Chhattisgarh, from where the soil has been taken for analysis. Out of the 6 macronutrients, only 3 micronutrients has been taken for research in Bastar region.

Materials and Methods

The present study was conducted in three stages *i.e.* soil survey and mapping, collection of samples and their analysis for different soil parameters. The soil samples were collected from 2 blocks viz, Jagdalpur and Darbha of Bastar district. From each block 3 villages Chingpal, Neganar, Lendra of Darbha block and Dhurguda, Babusemra, Khamargaon of Jagdalpur block, respectively, were selected. 12 samples were collected with different depths (0-15cm, 15-30cm). Statistical analysis was done using standard analysis of variance. Bastar is a district of Chhattisgarh. Bastar is located at 19.07°N 82.03°E. It has an average elevation of 552 metres (1811 feet) & height of 2000 ft plateau from sea level. The city is located on the south bank of the Indravati River. The district has an area of 14974 sq km. The average annual rainfall of the region varies between 1200-1400 mm.Bastar has a monsoon type of hot tropical climate. Summers last from March to May and are hot, with the average maximum for May reaching 38.1 °C (100.6 °F). The weather cools off somewhat for the monsoon season from June to September, which features very heavy rainfall. Winters are warm and dry. Bastar district average rainfall is 1324.3 mm. Its average temperature in summer is 33.15°C, and in winter is 20.73°C.

Results and Discussion

The **Table 1** depicted the Soil Texture (Sand, Silt and Clay %) of different villages of Bastar Plateau regions, Chhattisgarh, the soil sample were taken on respective depths (0-15 and 15-30 cm). The soil texture-sandy clay loam was found in all the two depths, 0-15 cm and 15-30 cm of villages, Babusemra and Dhurguda, and soil texture-silt clay loam was found in all the two depths, 0-15 cm, and 15-30 cm of villages, Chingpal, Neganar, Lendra, and Khamargaon. The sand, silt and clay percentage varied from 60 – 65% sand, 10 - 15% silt and 20 – 25% clay in sandy clay loam and 18–35% sand, 40-50 % silt and 30–35% clay in clay loam. [19]

Table 1 Evaluation of Soil Texture (Sand, Silt and Clay %) of different depth (0-15 and 15-30cm) of different villages of Bastar Plateau regions, Chhattisgarh, India (2014-15)

Villages	0-15 cm	15-30 cm
V_4- Chingpal	Sand-35.75%, Silt-32.30%, Clay-38.00% Clay loam	Sand-35.05%, Silt-32.00%, Clay-36.00% Clay loam
V_5- Neganar	Sand-25.95%, Silt-45.05%, Clay-36.25% Clay loam	Sand-35.00%, Silt-42.40%, Clay-22.60% Clay loam
V_6- Lendra	Sand-35.25%, Silt-38.85%, Clay-25.90% Clay loam	Sand-40.00%, Silt-30.00%, Clay-30.00% Clay loam
V_7- Babusemra	Sand-40.00%, Silt-32.65%, Clay-27.35% Clay loam	Sand-38.23%, Silt-30.00%, Clay-31.77% Clay loam
V_8- Khamargaon	Sand-65.20%,S ilt-12.75%, Clay-22.05% Sandy clay loam	Sand-65.00%, Silt-12.75%, Clay-22.25% Sandy clay loam
V_9- Dhurguda	Sand-58.62%, Silt-15.37%,Clay-26.01% Sandy clay loam	Sand-58.32%, Silt-15.67%,Clay-26.01% Sandy clay loam

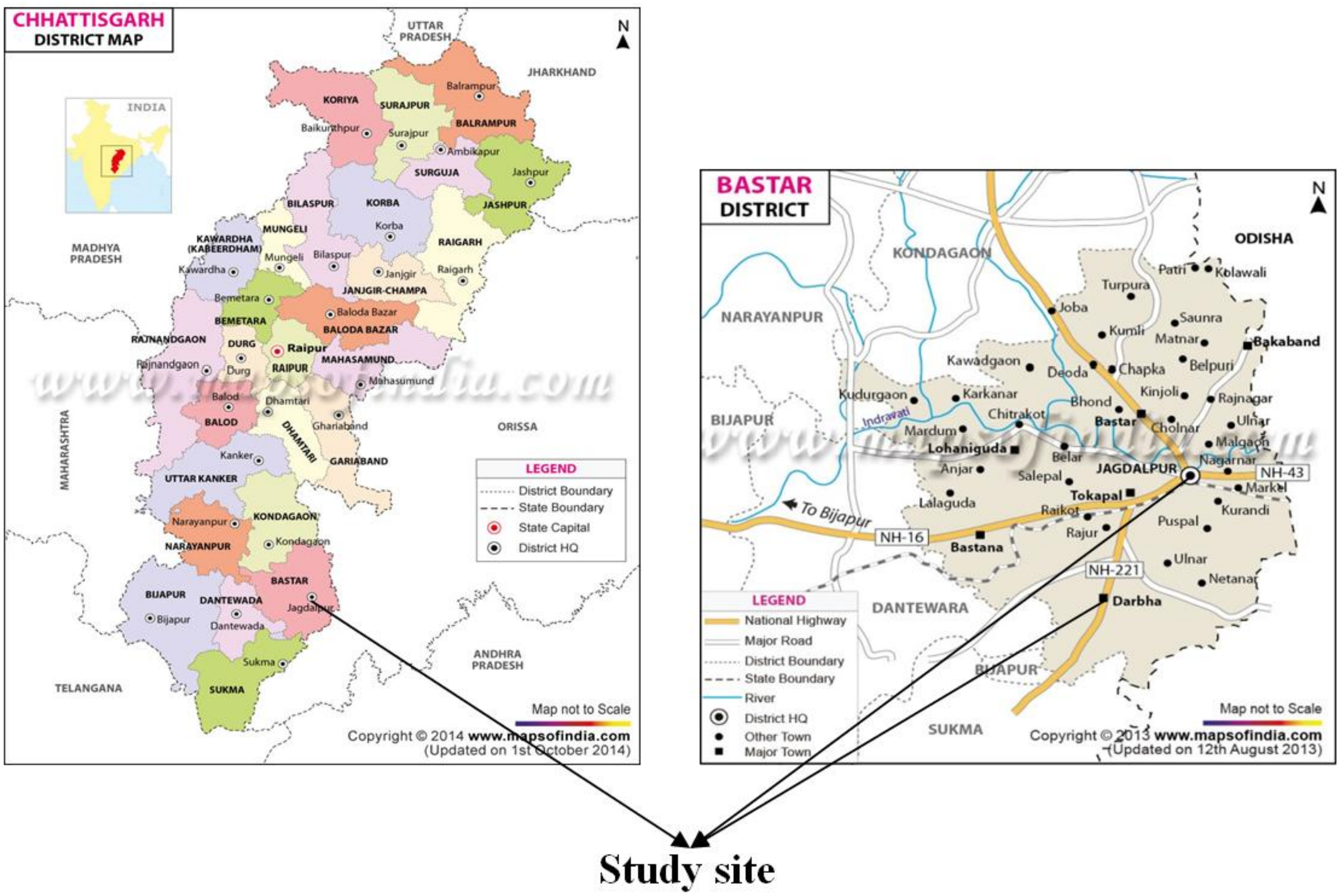

Figure 1 Map of Bastar district

Of the following soils, the pH was determined in 1:2 soil water suspensions using Digital pH Meter [13]. The EC was determined in 1:2 soil water suspensions using Digital Conductivity Meter [27].The observations regarding pH, EC, Organic Carbon, Nitrogen, Phosphorous, Potassium extracted from soil are given in **Figure 2-4** and **Table 2**. The Figure 2 depicts -the statistical accumulation of pH on villages and depths which was found to be significant at both levels. The highest value of pH is found in Chingpal village at depth 0-15cm (6.5) and at depth 15-30cm (6.1). Similar results were reported by [24].The organic carbon was determined by Wet Oxidation Method (Walkley 1947). Available nitrogen is a term used to described the fertilizers. The available N <250 kg ha^{-1} may be interpreted as low, 250-500 kg ha^{-1} as medium and >500 kg ha^{-1} as high. The soil was distilled with alkaline potassium permanganate as suggested by [21] and the ammonia evolved was determined. The available phosphorous was extracted from soil by

0.5 M $NaHCO_3$ (pH 8.5) solution. Phosphorous in the soil extract is determined colorimetrically using a Photoelectric Colorimeter after developing molybdenum blue colour [18]. The exchangeable potassium is extracted from 1N NH_4OAC (pH 7.0) and K was determined by Flame Photometer [23].

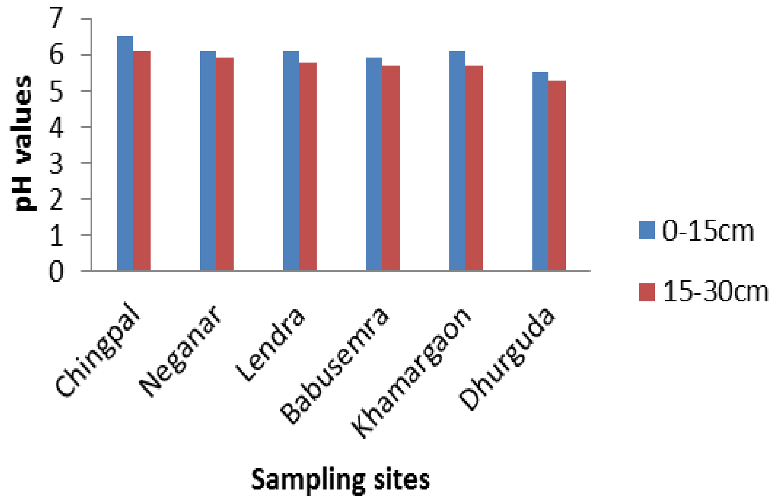

Figure 2 pH values of soil of Bastar plateau regions, Chhattisgarh at (0-15cm, 15-30cm) depths, 2015

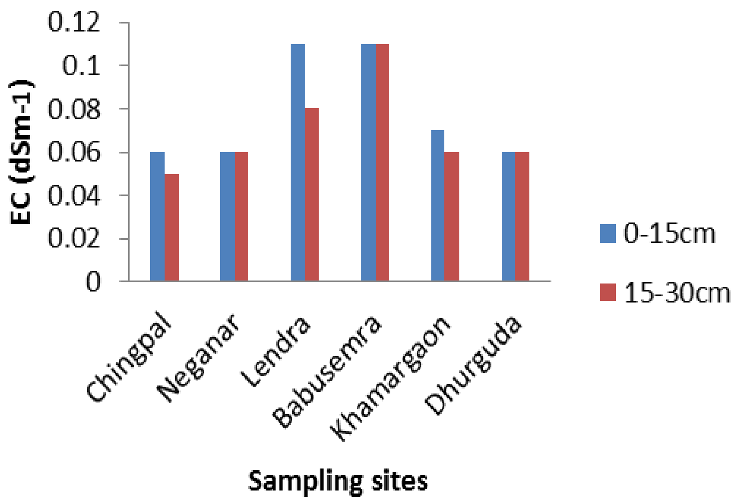

Figure 3 EC values of soils of Bastar plateau regions, Chhattisgarh at (0-15cm, 15-30cm) depths, 2015

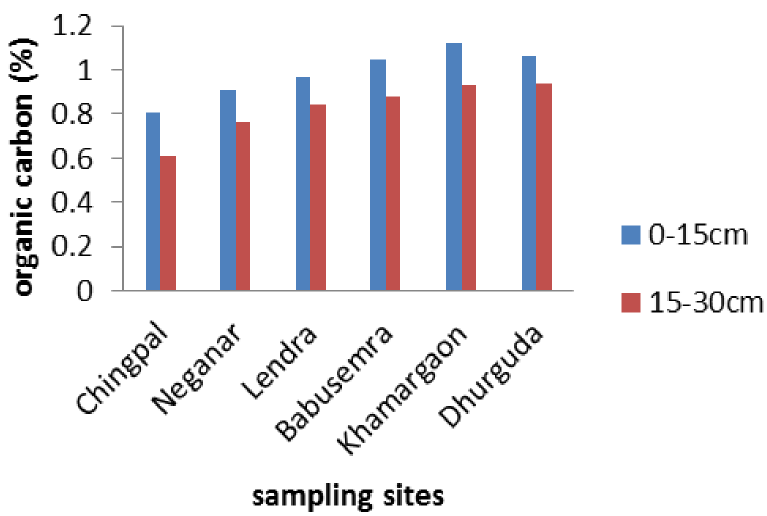

Figure 4 Organic Carbon percentage of soils of Bastar plateau regions, Chhattisgarh at (0-15cm, 15-30cm) depths, 2015

Table 2 Available Nitrogen (kg ha^{-1}), Phosphorous (kg ha^{-1}), Potassium (kg ha^{-1}) of soils of Bastar plateau regions, Chhattisgarh at (0-15cm and 15-30cm) depths, 2015

S.No.	Villages with different depths	Available Nitrogen (kg ha^{-1})	Available Phosphorous (kg ha^{-1})	Available Potassium (kg ha^{-1})
1.	Chingpal (0-15cm)	251.49	8.51	161.67
2.	Chingpal (15-30cm)	201.19	9	148.67
3.	Neganar (0-15cm)	226.34	8.01	229.03
4.	Neganar (15-30cm)	213.76	9.12	202.09
5.	Lendra (0-15cm)	238.9	8.75	242.5
6.	Lendra (15-30cm)	188.6	7.62	229
7.	Babusemra (0-15cm)	276.6	10.7	202
8.	Babusemra (15-30cm)	238.9	9.1	188.5
9.	Khamargaon (0-15cm)	251.49	10.71	121
10.	Khamargaon (15-30cm)	213.76	7.62	107.78
11.	Dhuguda (0-15cm)	238.91	10.72	148.2
12.	Dhurguda (15-30cm)	226.34	9	134.72

The total soluble salt content i.e. EC in villages and depths was found to be significant at both levels. The highest value of EC is found in Babusemra at depth (0-15cm) 0.11dSm^{-1} and at depth (15-30cm) 0.10dSm^{-1}.Similar results were reported by [24].

The accumulation of organic carbon % in villages and depths were observed to be significant at both levels. The highest value of organic carbon is found to be in Khamargaon at depth (0-15cm) 1.12% and Dhurguda at depth (15-30cm) 0.94%. Similar results were observed by [14].

The accumulation of available nitrogen on villages and depths was found to be significant at both levels. The highest value of nitrogen was observed to be in Khamargaon and Chingpal at depth (0-15cm) 251.49 kg ha^{-1} and Dhurguda at depth (15-30 cm) 226.34 kg ha^{-1}. Similar results were reported by [24].

The accumulation of available phosphorous on villages and depths was found to be significant at depth. The highest value of Phosphorous is found in Dhurguda at depth (0-15cm) 10.72 kg ha^{-1} and, Neganar at depth (15-30cm) 9.12 kg ha^{-1}. Similar results were reported by [14].

The accumulation of available potassium on villages and depths was found to be significant at both levels. The highest value of Potassium is found to be at Neganar at depth (0-15cm) 229.03 kg ha^{-1} and Lendra at depth (15-30cm) 229 kg ha^{-1}. Similar results were reported by [24].

Conclusion

The reduction in the pH is due to production of acids by bacterial action in aerobic or due to nitrification processes taking place in the soil. The low EC may be due to good drainage conditions which favored the removal of bases by percolation. [20] recorded EC value 0.5 dS m^{-1} for a good soil. The organic C content decreased with depth in all the villages and this is due to the addition of more plant residues and farmyard manure being added to the surface horizons than as compared to that in the lower horizons [17]. Maximum Available N content was observed to be in surface horizons and decreased regularly with depth which was due to the decreasing trend of organic C with depth and as the cultivation of crops are mainly confined to the surface horizon (Rhizosphere) only. At regular interval the depleted nitrogen content is supplemented by the external addition of fertilizers during crop cultivation [19].However, the highest P content was observed in the surface horizons and decreased with depth. It might be due to the confinement of crop cultivation the rhizosphere and supplementing the depleted P by external sources *i.e.*, fertilizers and presence of free iron oxide and exchangeable Al^{3+} in smaller amounts [22]. The lower P content in sub-surface horizons compared to surface horizon was due to the fixation of released P by clay minerals and oxides of iron and aluminium. The highest K content was observed in the surface horizons and showed more or less decreasing trend with depth. This might be a attribute to more intense weathering, release of liable K from organic residues, application of K fertilizers and upward translocation of K from lower depths along with capillary rise of ground water.

References

[1] Anonymous, (2008) Harmonization of wasteland/degraded lands datasets of India. Wasteland News, XXIII, No. 4, pp. 50-53

[2] Anonymous, 1971 Munsell Soil Colour Chart. Munsell Color Company Inc. 2441 N, Calvert Street, Baltimore, Maryland 21212, USA.,

[3] Basava , R., D., Naidu, M.V.S.. Ramavatharam, N., Vankalah, K, Rama, Rao, G. and Reddy, K.S. (2005) Characterization classification and evaluation of soils in Chandragiri mandal of Chittoor district, Andhra Pradesh. Agropedology, 15:55-62

[4] Bhaskar, B.P. and Nagaraju, M.S.S. (1998) Characterization of some salt affected soils occurring in Chitravathi river Basin of Andhra Pradesh. J. Indian Soc. Soil Sci.,46:416 -421.

[5] Black,C. A. (1965) Methods of soil analysis Vol.1. American Society of Agronomy, Madison, Wisconsin USA.

[6] Bouyoucos, G.J. 1927 The hydrometer as a new method for the mechanical analysis of soils. Soil Sci. 23: 343-353.

[7] Brady, N.C. and Weil, R.R. (1996) The nature and properties of soils (11th ed.). Prentice Hall, New York.

[8] Chibba, I. M. and Sekkhon, G.s. (1985) Effect of pH and organic carbon on – availability of nutrients in acid soils. Journal of the Indian Society of Soil Science. 33: 409-411.

[9] De Vos, J. H. and Virgo, K. J. (1969) Soil structure in Vertisols of the blue clay plains, Sydan. Journal of Soil Science 20: 189-206.

[10] Gupta, G.P., Tembhare, B.B. and Mishra, S.R.(1999) Characterization and classification of soils of granitic terrain in Jabalpur district of Madhya Pradesh. Agropedology, 9:77-81.

[11] Gupta, S.K. and Chara, R.S. (1996) Soil characterstics as influenced by by slope aspects in middle siwaliks. Agropedology. 6:43-48.

[12] Haruna, S. I., and Nkongolo, N. V. (2013) Variability of Soil Physical Properties in a Clay- Loam Soil and its implication on Soil Management Practices. Hindawi Publishing Corporation, 10:1-8

[13] Jackson, M.L. 1958 Soil Chemical Analysis. Prentice Hall of India. Private Ltd., New Delhi (1973)

[14] Kumar, A., Mishra, V. N., Srivastav, L. K., and Banwasi, R. (2014) Evaluations of soil fertility status of available major nutrients (N,P & K) and micro nutrients (Fe, Mn, Cu & Zn) in Vertisols of Kabeerdham District of Chhattisgarh, India. International Journal of Interdisciplinary and Multidisciplinary Studies, 1(10):72-79.

[15] Munshower (1994) Practical handbook of land revegetation. Lewis publication, Boca Raton, Florida.

[16] Mukesh Kumar, S.R. Yadav and Mangilal (2017) Relationship between Soil Physico - Chemical Properties and Available Macronutrients in Loamy Sand Soils. Chem Sci Rev Lett 2017, 6(21), 153-158

[17] Nayak, D.C., Sarkar, D. and Das, K. (2002) Forms and distribution of pedogenic iron, aluminu and manganese in some Benchmark soils of West Bengal. Journal of the Indian Society of Soil Science 50, 89-93.

[18] Olsen, S.R., Cole, C.V., F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate U.S. Deptt. Agr. Circ. 939

[19] Satish Kumar, Y.S. and Naidu, M.V.S. (2012) Characteristics and classification of soils representing major landforms in Vadamalapeta mandal of Chittoor district, Andhra Pradesh. Journal of Indian Society of Soil Science 60, 63-67.

[20] Singaravel, R. and Govindamsamy, R. (2000) “Practical manual for soil fertility, fertilizers and manures.

[21] Subbiah B.V. and C.L. Asija 1956 A rapid procedure for the estimation of available nitrogen in soils. Current Sci. 25: 259-260.

[22] Thangasamy, A., Naidu, M.V.S., Ramavatharam, N. and Raghava Reddy, C. (2005) Characterization, classification and evaluation of soil recources in Sivagiri micro – watershed of Chittoor district in Andhra Pradesh for sustainable land use planning. Journal of the IndianSociety of Soil Science 53, 11-21.

[23] Toth, S.J. and A.L. Prince (1949) Use of the flame photometer in rapid soil tests for K and Ca. Argon. J. 41: 445-446

[24] Upadhyay, M., and Chawla, J. K. (2014) Chemical characteristics of soil in parts of Dhamtari District of Chhattisgarh. IJMCA, 4(13): 146-149.

[25] Wagh, G. S., Chavhan, D. m., and Sayyed, M. R. G. (2013) Physicochemical analysis of Soils from Eastern part of Pune city. Universal Journal of Environmental Research and Technology, 3(1): 93-99.

[26] Wang, Y., Huang, T., Lin, Z., Li, S., Wang, R., and Ce, Y. (2015) Soil pH value, organic matter and macronutrients contents prediction using optical diffuse reflectance spectroscopy. Computers and Electronics in

Agriculture, 1(11): 69-77.
[27] Walkley and Black 1934; Walkley (1947) Wet Oxidation Method for estimation of soil organic carbon.
[28] Wilcox L.V. 1950 Electrical Conductivity, Amer. Water Works Assoc. J. 42: 775-776

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