Influence of graphite powder on soil Cation Exchange Capacity using Cohex method and impact of graphite powder on soil Physical and Chemical properties

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Abstract

Cation Exchange Capacity (CEC) of a soil is a dynamic property that varies with the physical and chemical properties of soil and estimating the CEC values using Cohex method that gives a reliable value to be used in soil physics. The CEC values of soil change with organic matter and increase with soil pH and soil textures which in turn depend on clay content and compaction. In this study, the physical and chemical properties of soil with and without graphite are estimated. The values of soil CEC, pH, electrical conductivity, soil nutrients viz., Ca, Mg, Na, K, soil organic matter, soil organic carbon and physical properties like bulk density, porosity, water holding capacity, particle density, soil aeration, % of pore space, using hexamine cobalt tri chloride (Cohex) as a reagent are estimated and reported. The studies are carried out on three different types of soil viz., black, brown and red soils collected from different areas.

Key words: Cation Exchange Capacity, Cohex, Soil organic matter, water holding capacity.

Introduction

Soils are composed of solids (minerals and organic matter), and pore space which holds air and water. The "ideal" soil would collect and hold sufficient air and water for plants in pore space for easy root penetration. Soil organic matter (SOM) plays a vital role in nutrient cycling and can help in the development of soil structure. Soil Cat ion Exchange capacity (CEC), nutrient holding capacity, nutrient acquiesce and constancy in turn influence water retentions and aeration. Soil bulk density (SBD) is a basic soil property influenced greatly by the amount of organic matter in soils, their texture, constituent minerals and porosity. Many researchers obtained the relationship between SBD and SOM contents of soil samples and obtained a strong correlation between them. Soil texture influences soil’s inbuilt fertility like physical properties, plant nutrients, water-holding capacity etc. Water holding capacity of soil in turn is directly governed by the soil texture. More nutrients can be absorbed by a clay particle than by sand or silt particles, because the clay particles provide much greater surface area for adsorption. The air in the pore spaces (Aeration) of a well structured, drained soil is composed of about 20% oxygen by volume; this is similar to the amount of oxygen (20.5%) in the atmosphere. Soil CEC is the total of the exchangeable cat ions that a soil can hold at a precise pH. The exchange sites are either pH-dependent or permanent depending on the nature of soil. Electrical conductivity (EC) is a measurement that correlates with soil properties that affects properties like crop productivity, including soil texture (ST), CEC, organic matter level, pH and available water-holding capacity respectively. Normally Sands have low conductivity, silts have medium conductivity, and clays have high conductivity. Consequently, EC correlates strappingly to soil particle size and texture.

The Hexamine Cobalt Tri chloride (Cohex) with its simple octahedral structure offers accurate results with tiny reagent excess though it is fairly large (its ionic radius is 0.323nm). The possibility of accurate measurements of CEC is obtained with Cohex. The CEC value obtained from Cohex method [1] is highly dependable, precise and this method is quite feasible and it possesses better Reproducibility

Carbon is an element in the periodic table that provides the origin for life on Earth. All carbon allotropes are solids under normal conditions with graphite being the most thermodynamically stable form. This increase in SOC resulted in the improvement of global economic conditions. Graphite powders increase crop yield through better seed planting. The graphite powder is also added to lubricate the mechanical parts of the planter exposed to the seeds. Based on these studies, it is intended to study the variation in the Soil Organic Carbon (SOC) that may lead to change in CEC of soil samples and the relationship can be established more accurately with the study by adding graphite powder.

Materials And Methods

Study Area (Black Soil): Perambalur (Padalur -Tamiladu, India) is located at an elevation of about 133.3 meters. It lies between 11˚14'00.59" of Northern latitude and 78˚52'59.85" of Eastern longitude. The mean maximum and minimum temperatures vary between 31° C and 20° C. The highest temperature ever recorded is 34° C and the lowest is 23° C. On an average, the district gets 861 mm of rainfall in a year. Perambalur receives a rainfall of 270 mm from South West Monsoon (June-Sep.) followed by high rainfall of 466 mm from North East Monsoon (Oct-Dec.).

(Brown Soil): Tanjore (Madhukkur -Tamilnadu, India) is located at an elevation of about 59 meters. It lies between 10º 08’ of Northern latitude and 78º 48’ of Eastern longitude. The mean maximum and minimum temperatures vary between 32° C and 23° C respectively. The highest temperature ever recorded is 35° C and the lowest is 24° C. On an average, the district gets 938 mm of rainfall in a year. Tanjore receives 329 mm rainfall from South West monsoon (June-Sep.) followed by a high rain fall of 462 mm from North East Monsoon (Oct-Dec.).

(Red Soil): Tiruchirappalli (Andanallur-Tamilnadu, India) is located at an elevation of about 90 meters. It lies between 10° 15’ and 11° 2’ of the Northern latitude and 78° 10’ to 79° 5’ of Eastern longitude. The mean maximum and minimum temperatures vary between 32.2° C and 21.2° C. The highest temperature ever recorded is 37.4° C and lowest is 24.7° C. On an average, the district gets 842.6 mm. of rainfall in a year. Tiruchirappalli receives 273.3 mm rainfall from South West monsoon (June-Sep.) followed by a high rainfall of 394.8 mm from North East Monsoon (Oct-Dec.).

Soil sampling and Physical - Chemical analyses

The aim of this study is to determine the CEC values of the soil with and without graphite powder and to establish its relationship with the soil properties. Before sampling, 15 mm top soil is removed. A composite sample of about 2 Kg is taken and sieved by sieve shaker with approximately 2 mm spacing to remove the coarser particles that are allowed to dry in air for an hour. The samples are analyzed for physico-chemical properties using standard procedures. The nutrient concentration and physical and chemical parameters of the soil samples are represented in Tables 3 and 4 respectively. SOM is obtained from the estimated SOC using the following conventional renovation.

$$OM = 1.5 \times OC \qquad \ldots\ldots\ldots.. \ (1)$$

The processed soil's texture is determined using the international pipette method, soil nutrients like Calcium, Magnesium and CEC by Cohex method, Sodium, Potassium by the Flame photometer, Organic carbon, Organic matter by the Walkley method and other soil physical characteristics such as bulk density, porosity, particle density and water holding capacity of soil by keen-Rackzowski box respectively.

The CEC is calculated using the relation Cation Exchange Capacity (C mol^{+}/Kg) = [(lb K ÷ 780) + (lb Mg ÷ 240) + (lb Ca ÷ 400)] × 1.10 (Factor Value)

Measurement of Electrical Conductivity and pH

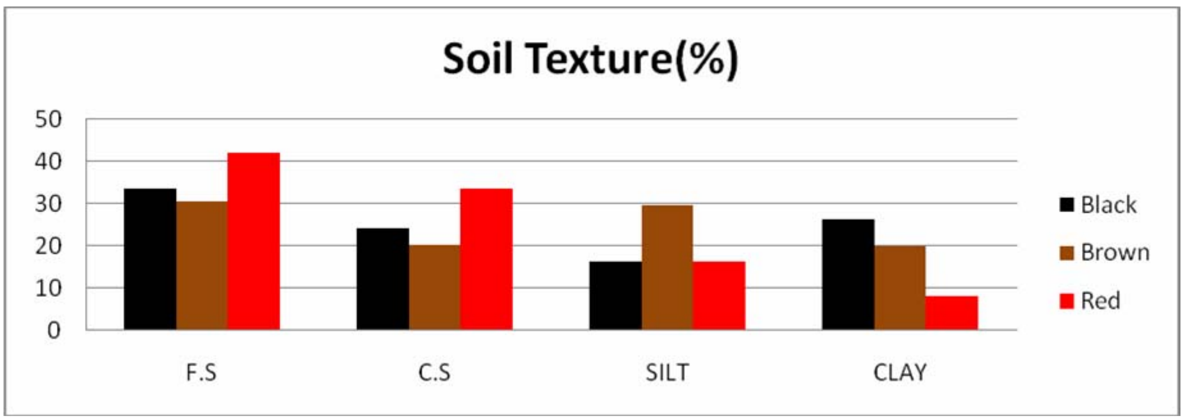
Electrical Conductivity (EC) and pH of soil samples have been measured by Electronic pH and EC meters. 20 gm of collected soil is weighed out into a 150 ml plastic jar and 100 ml distilled water is added. The lid of the jar is packed tightly and the content is stirred using Magnetic Stirrer continuously for 5 minutes. It is kept overnight and stirred repeatedly. The content is allowed to settle for 15 minutes and EC and pH readings are taken for the strained samples.

Result and Discussion

Relation between Soil Texture and CEC, SOM, SOC

The relationship between changes of CEC and SOM is not only the effect of different textured fractions on soil CEC but also examined the different values of Soil organic carbon and organic matter and its variations [2]. It is noted that CEC of different soil textured fractions for different Soils Black, Brown and Red, were closely correlated with SOC concentrations in black soil treatments compared with whole Brown and Red soil samples. The largest CECs were related with the soil textured fractions (Fine sand, Course sand, Silt, Clay)[3]. The Pearson correlation showed that the correlation between SOM, SOC and the CEC of the Graphite added Black soil samples (R = 0.962) are compared well with that of graphite added Brown (R=0.974) and Red (R = 0.922) soil samples. The Particular prominence on the effect of the fine fractions (<2 µm and 2-20µm) on CEC the Black soil (depth 30cm) samples and the CEC of all (Black, Brown, Red) soils and fine fractions are closely correlated with the respective CEC[4].The correlation coefficients between the fractions and SOC content are highly significant (P=0.009 for Black soil, P= 0.005 for Brown soil and P= 0.026 for Red soil).

The fine sand, course sand, and silt, clay fractions of Black, Brown, Red soil samples are seen as the essential fraction as they determined the differences between the soil samples Fig.1, whereas the clay fraction was the only fraction where the mineral component seemed to have significant input to CEC, and SOM and explained only 5% of variation. The Red soils have relatively low clay content (7.98%) followed by black soils, where the clay content is 26.2%. The Fine Sand content of the Red soils is higher (42.18%). The Course Sand content of the Red soils is 35% and the silt content of the Brown soils is 30% as in Fig.1. It shows the specific variation among the raw soil samples (soil+cohex).



(F.S-Fine sand; C.S-Course sand) Fig.1 Soil Texture (%)

The higher CEC values Versus OM, OC of Black soils are due to the application of Graphite powder when compared with that of Graphite powder added Brown, Red soil samples as in Fig.2 and Fig.3 respectively.

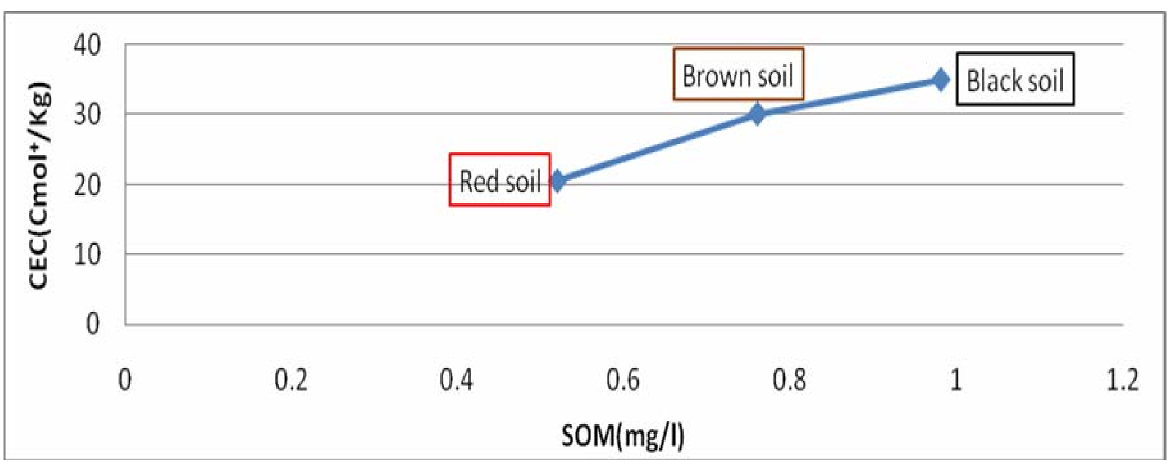


Fig.2 SOM Vs CEC

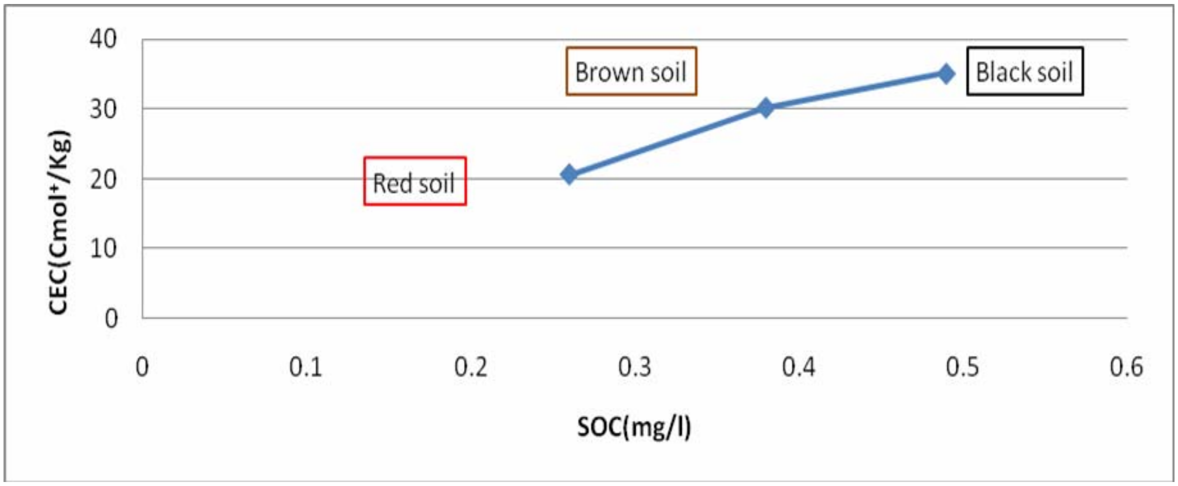


Fig.3 SOC Vs CEC

Relationship between Soil CEC and EC and pH

The soil pH is reported to influence soil CEC investigated only the effect on the CEC with whole soil fractions [5]. Graphite powder is added with soil samples of all soil (Black, Brown, Red) samples in different proportions (5% - 25%), the pH values of Graphite powder added soil samples are greater than the pH values of raw soil (Soil+cohex) samples Fig.4, Fig.5. and the Electrical Conductivity (EC) of the soil sample is significant ($P\leq 0.05$) and negatively correlated with CEC, when the soil sample is added with graphite powder.

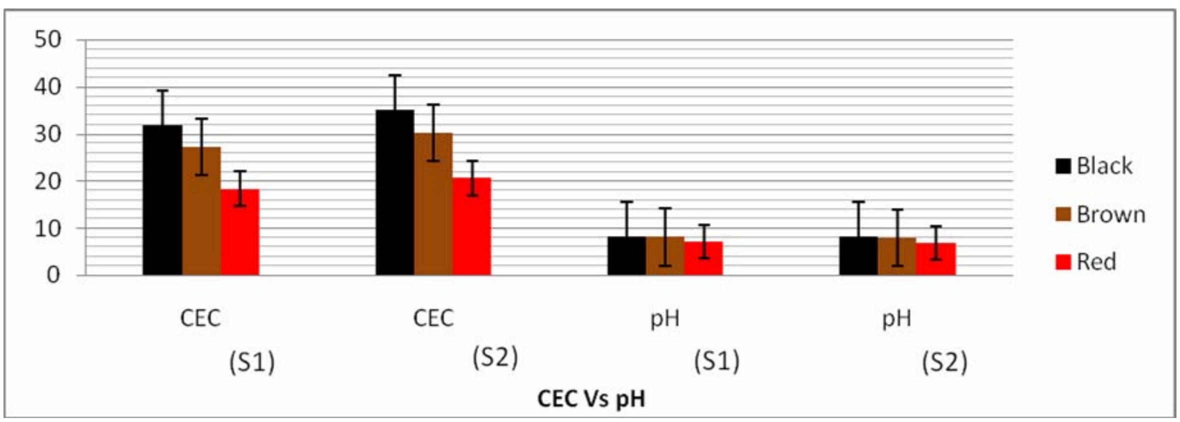


Fig.4 pH Vs CEC

Relationship between Soil Texture and Soil Physical properties and Nutrients of soil samples

Many researchers obtained the relationship between Soil Organic Matter (SOM) content and bulk density (BD) of soil samples that showed a strong correlation between them and a reverse correlation between organic matter and bulk density[6].The strongest correlation exists between bulk densities and organic matter along with the data attained from the analysis results[7,8].

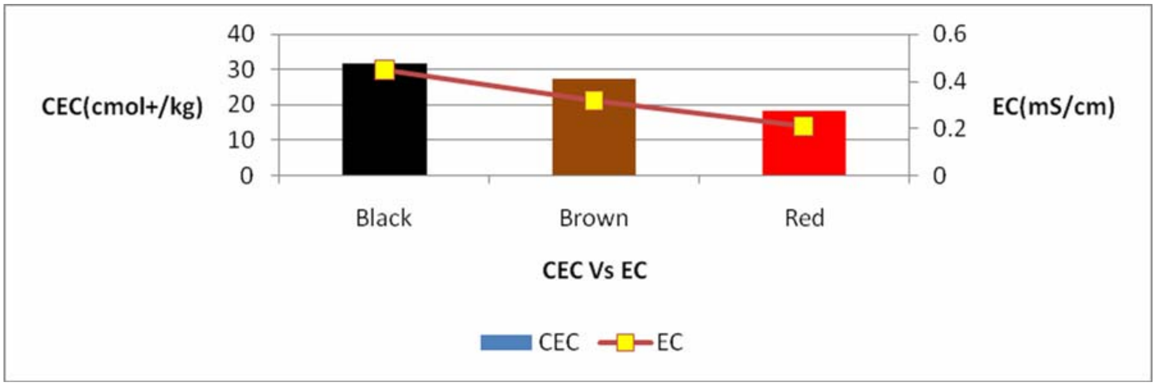


Fig.5 CEC Vs EC

In this study these related results were obtained with strong negative correlation (Black Soil R = -0.972; Brown Soil R= -0.985; Red Soil R= -0.960) between organic matter and bulk density of soil samples. Thus, the studies indicate that as the Soil organic matter increases, the bulk density of the soil decreases which is an attractive condition for the proper growth of the plants.

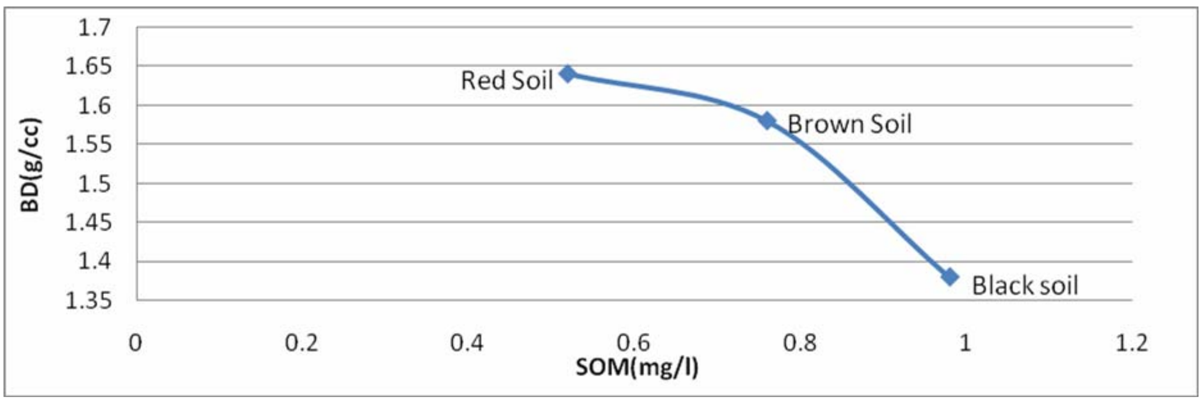


Fig.6 SOM Vs BD

The changes in porosity negatively affects soil Bulk density and Particle density and plant rooting behaviour and changeability in particle density [9]. In soil science, the particle densities are infrequently measured. Instead, the value of particle density is usually assumed as 2.65 g/cm3. The lower particle density could account for the simultaneous reduction of bulk density. Difference in particle density can be substantiated for the changes in mineralogy over a relatively short period of time with perhaps different systems promoting the loss and gain of minerals of different densities. highest (2.02 g/cm3) mean value of particle density is obtained from graphite added soil samples. Water holding capacity (WHC) of soil is directly governed by the soil texture. The water retention and transmission Change according to soil texture [10]. Soil Organic matter and Organic carbon improves water holding capacity of soil samples which also suggests the positive Correlation (Table 3) with WHC of the Graphite powder added soil (Black, Brown, Red) samples. Water Holding Capacity (WHC) is positively and significantly ($P \leq 0.05$) associated with the exchangeable basic cat ions (Ca, Mg and Na) and CEC of the soils. The Cat ion

Exchange Capacity (CEC) of soils (Black, Brown, Red) samples are increased by increasing the nutrients like K+ and Ca+ + and Mg+ +and Na+ and these are very important for both the plant root and soil interface within the plant Fig. 8,9,10,11. The value of soil aeration of Graphite Powder added Red soil sample is high compared to raw soil sample Fig.7. Soil aeration is significant (P ≤05) and positively correlated with CEC and other soil physical properties.

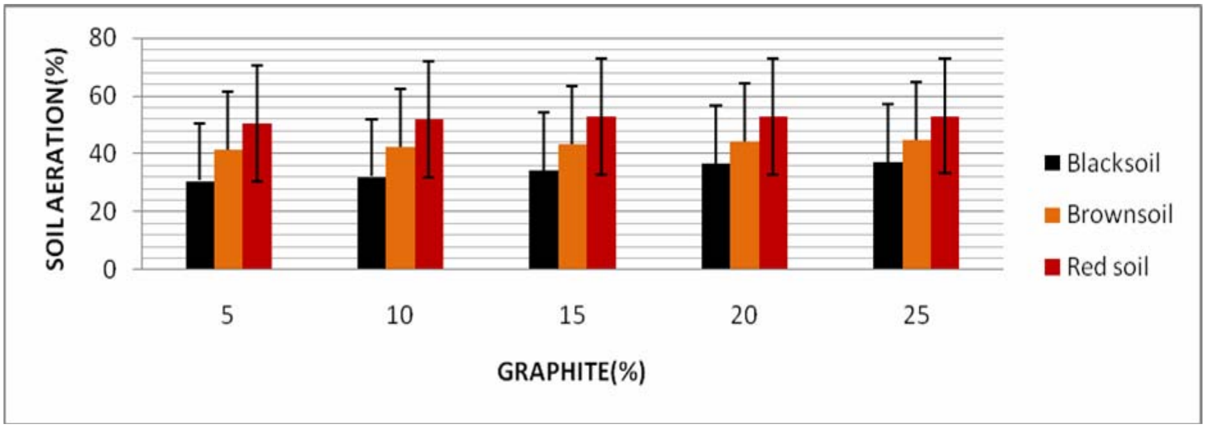


Fig.7 Soil Aeration Vs Graphite

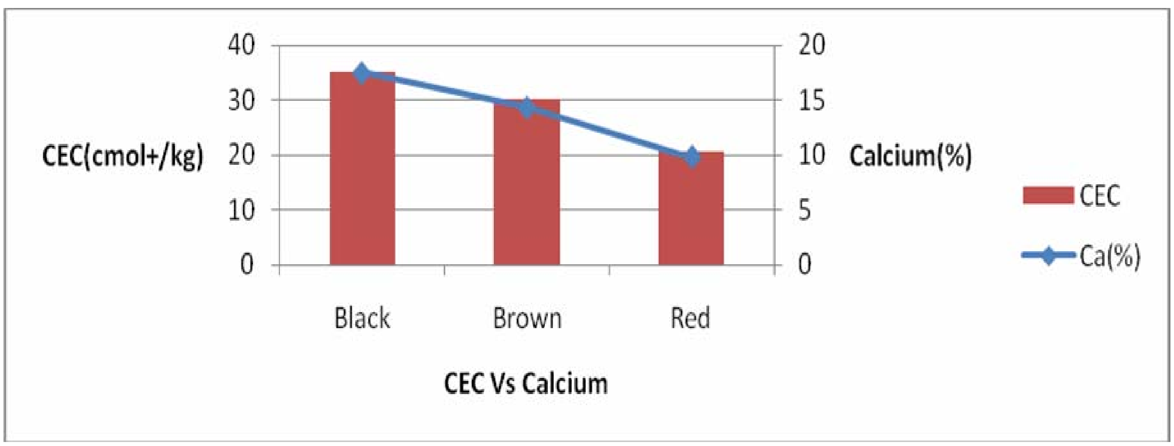


Fig.8 CEC Vs Ca

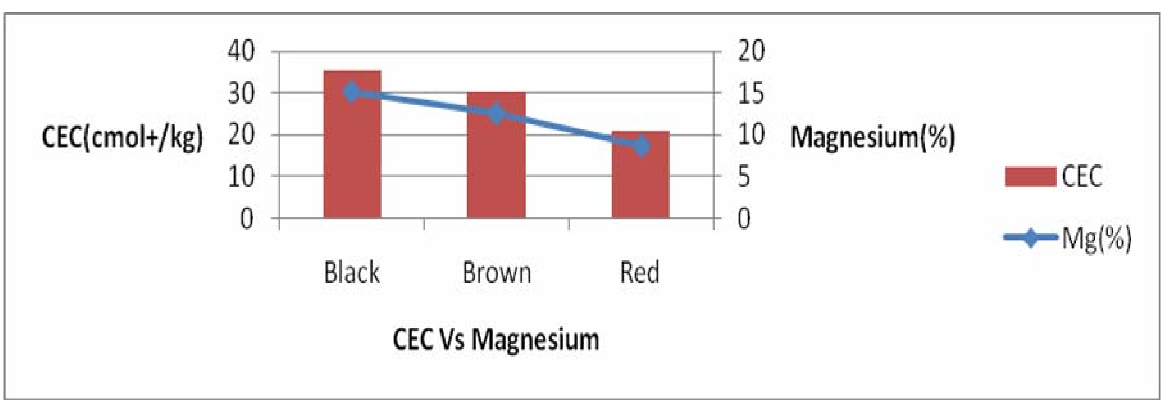


Fig.9 CEC Vs Mg

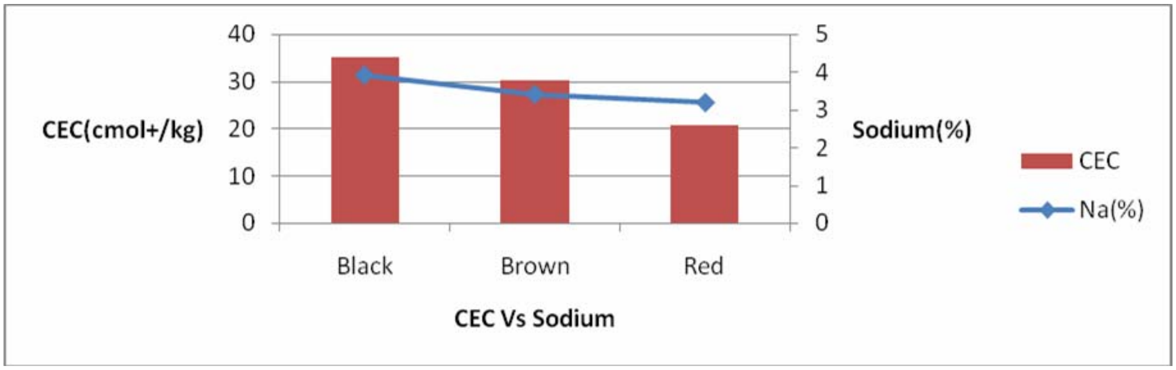


Fig.10 CEC Vs Na

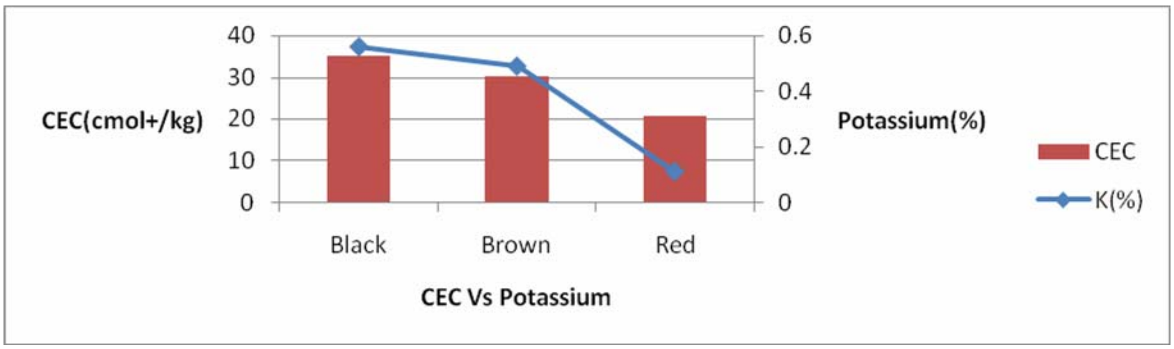


Fig.11 CEC Vs K

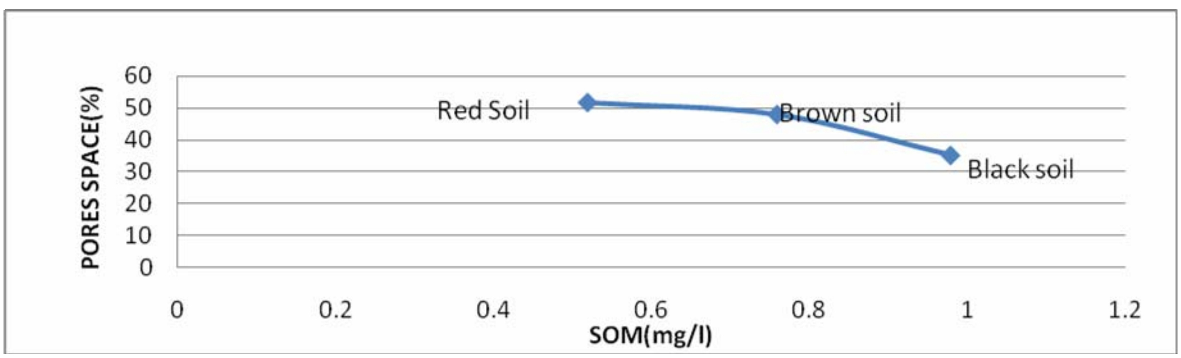


Fig.12 SOM Vs % Pores space

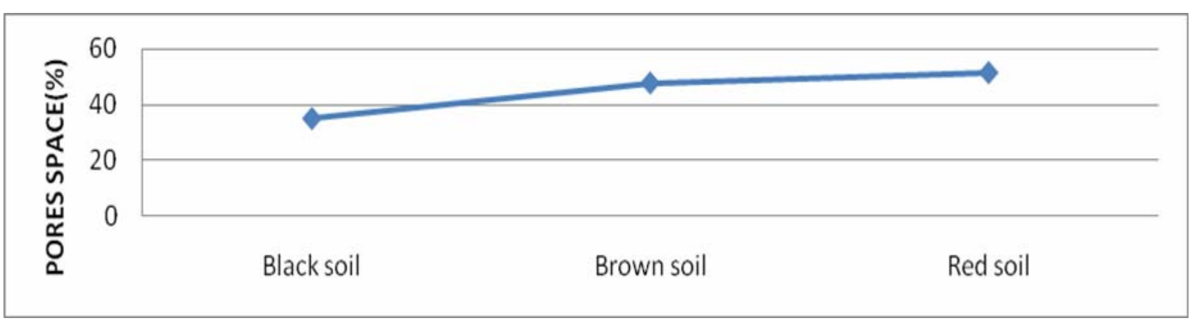


Fig.13 Pores Space (%)

The pore space provides proper opportunity for water and flow of nutrient. The fertility of the soil depends upon the soil characters which are mainly controlled by the macro and micro pore spaces. The percentage of pores space values of the Graphite powder added Brown, Red soil samples show relatively high compared to Graphite powder added Black soil sample value fig.13 and it can be seen that the concentration of organic matter depends extensively on the pore space. The macro pore space of soil has low concentration of organic matter and the Pore space of the Graphite powder added Red soil has higher and lower concentration of organic matter that may have considerable improvement in the flow of nutrients and provide a better environment for plant growth.

Conclusion

The CEC value obtained from Cohex method is highly dependable, precise and optimized. Further, this method is quite feasible, it possesses good repeatability and the results are reported. The CEC of different soil Texture fractions of Black, Brown and Red is closely correlated with SOM and SOC concentrations in soil treatments. CEC of graphite powder added soil samples increase with increasing soil porosity, water holding capacity, soil aeration and percentage of soil pore space respectively. Graphite added soils CECs are negatively correlated with soil pH, EC, Bulk Density and Particle Density. The CEC of graphite powder added soil (Black, Brown and Red) samples are increased by increasing the nutrients like K+ and Ca+ + and Mg+ +and Na+ and these are very essential for both the plant root and soil interface with the plant. This study shows that increased SOC under certain management systems can affect a variety of soil properties (physical and chemical) as it is associated with the addition of graphite powder with the soil. It aids in retaining and supplying nutrients like Ca, Mg, Na and K and enhances water holding capacity. These upgrading studies clearly illustrate that SOM, SOC play a significant role in determining soil CEC and the suitability of employing Cohex method for such estimatins.

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