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A GEOMETRICAL APPROACH FOR CHARACTERIZATION OF SOIL CALCAREOUS IN SEMI-ARID REGION OF TELANGANA STATE, INDIA

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ABSTRACT

Soils containing a high amount of calcium carbonate are identifying as calcareous soils. This type of soil severely affects the plant's growth as they tend to be low in nutrient availability and organic matter. An extensive study was conducted to characterize the calcareousness in Zaheerabad Mandal, Telangana State, India. A total of 48 geo-referenced soil samples were collected in five villages and analyzed for soil texture, soil-water availability, hydro geomorphology, and free calcium carbonate. GIS-based soil characterization is done with Arc GIS - 10.3 software and verified with the ground truth data. The observations showed that 34.14 % of the study area is affected with 35-60% of soil calcareousness, which indicated high calcareousness, followed by slight soil calcareousness in 32.42 % of the study area, i.e., 15-35% of calcareousness and 31.54% of the study area is free from calcareousness. This characterization of soil calcareousness alarmed the inferior cultivation methods in the study area and alerting the farmers for better land management by avoiding high pH substances such as pesticides and synthetic fertilizers.

KEY WORDS : Soil Calcareousness, Soil texture, Soil - water availability, Hydro geomorphology, Calcium carbonate

INTRODUCTION

The quantity of calcium carbonate present in the soil indicates the calcareousness of the soil. Nowadays, calcareous soils covering almost 30% of the earth's surface, and the level of calcium carbonate in these areas varies widely from a few "%" to "95%" (Marsh, 2003; Silvestri *et al.*, 2020). A large amount of calcium carbonate in soils affects the various soil properties related to the plant's growth, such as nutrient availability, soil crusting, soil - water capacity, etc. (Song *et al.*, 2019). The desert, arid, and semi-arid countries mainly contain calcareous soils due to two reasons. The first is naturally available rich calcium like basalts, and the second reason is the frequent alteration of dry and wet periods. These long dry seasons generally not favourable to deep leaching the solutions in soils. This type of soil usually has a pH above "7", and in some cases, pH may reach "8.5". If the soils contain sodium carbonates, then the pH may cross "9" also. $CaCO_3$ can concentrate into tough layers in some soils, termed caliche, which is impermeable to water and plant roots (Cross, 2017). The availability and quality of irrigation water in low rainfall regions lead to constraints in the agricultural sector and create several irrigation management problems. The water from all the sources naturally contains various inorganic salts. These salt substances from irrigation water enter into soil profile considerably to such high concentrations and then show their impacts in multiple forms. These may modify soil structure,

disturbs the soil - water permeability, and alter plant growth (Ma *et al.*, 2021). Simultaneously, high levels of calcareousness also affect the infiltration capacity, aeration process due to surface crusting.

The occurrence of calcium carbonate directly or indirectly affects the availability of nutrients such as nitrogen, magnesium, calcium, potassium, phosphorous, iron, zinc, and copper (Rasha *et al.*, 2005). The high pH of calcareous soils affects the loss or fixation of some nutrients available in soil. Hence, fertilizer management in calcareous soils differs from the non - calcareous soils. The extensive occurrence and specific characterization of soil calcareous are essential to find practical solutions leading to better utilization and management of soil and water management practices (Sakram *et al.*, 2020). This paper summarizes the results of extensive research work carried out in the Zaheerabad Mandal villages of Telangana state, India, to investigate the impact of calcareousness, enhancing economically viable sustainable production of central cropping systems.

MATERIALS AND METHODS

The study area is located in Zaheerabad Mandal and covers 7793 hectares of area with Hothi (K), Huggelli, Ranjole, Raipalle PD, Shaikapur villages. The Survey of India (SOI) Topographic map NOs. 56 G/6, 56 G/9, and 56 G/10 of scale 1:50000 along with IRS P6 LISS IV data were used to prepare thematic maps such as Land use/Land cover, Hydro geomorphology, soil depth, soil, soil texture, the available capacity of soil-water, and Soil calcareousness (Anji *et al.*, 2013).

Soil calcareousness is determined using the Vinegar test method in the study area (Chaney *et al.*, 1982). Soil samples were collected and dried at room temperature for one week. In these soil samples, large pieces of organic residues and gravel, etc., are removed. Ten drops of distilled water is added to one full cap (0.8 tsp volume) of soil sample to make the soil wet. Into this, Ten drops of White vinegar with 5% acidity are added slowly with the eye dropper's help and stirred well, and observed the release of vigorous bubbles. After five minutes, the adding of White vinegar continued until the bouncy bubbles became weak, and counted the number of White vinegar drops. Finally, total drops of vinegar added to one cap of soil indicates the presence of carbonate concentration in soil sample (Table 1).

Table 1. Soil carbonate estimation with the vinegar test for Calcareousness

Total drops of White vinegar for one cap of soil	% of Carbonate concentration
< 10	< 02
40–70	05
100–150	10
200–320	20
410–650	40

RESULTS AND DISCUSSION

Land use classification from the Figure-2 shown that 14.42% of the study area identified with "Double crops," 1.42% of an area identified with "Fuelwood species." And 41.42% of the study area is observed as "Kharif un irrigated," followed by 31% of the area with "Land with scrub" category, 1.13% of the area with "Plantation" category, and 10.44% of the study area with "Scrub Forest" category. The area under the "Water Bodies" category is 1.1% in the study area's geographical location. The study area's hydro geomorphologic study identified 35.39% of the study area observed as "Moderately thick laretritic plateau" and having moderate to good groundwater potential. 23.14% of the study area is identified with "Moderately thick laretritic valley," It has average groundwater potential, and 41.47% of the study area is identified with "Thick laretritic plateau" and having inferior to moderate groundwater potential.

Surface soil texture illustrates the delicate nature or course nature of the soil. It also explains soil's physicochemical characteristics, soil-water relation, infiltration capability, drainage, and nutrient availability. As per Ditzler *et al.* (2017), Surface soil texture classification is carried out in the study area.

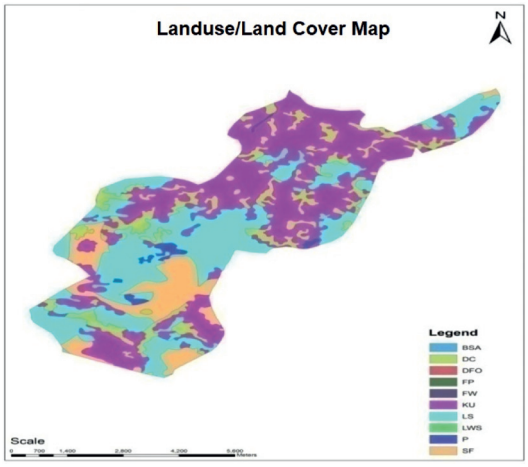

Fig. 1. Land use/Land cover Map

Graveline soils with a combination of clay soil texture are present in 52% of the geographical area, clay soil texture is current in 24.43% of the study

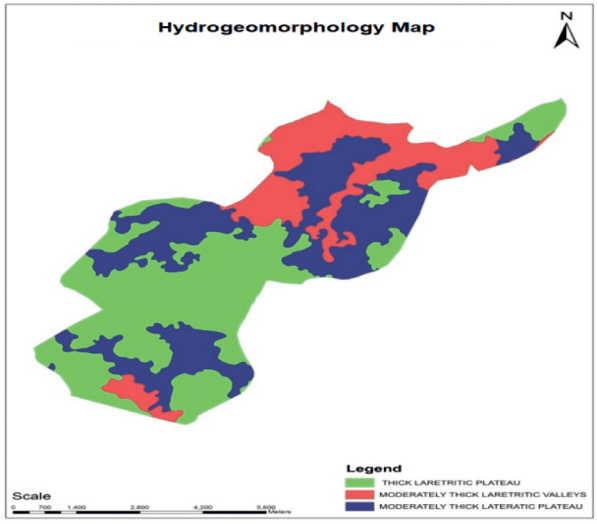

Fig. 2. Hydrogeomorphology Map

area, and Graveline surface soil texture is present in 4% of the geographical location.

Soil-water available capacity mostly depends on rainfall pattern, surface water sources, soil texture, infiltration capability, etc. (Jackson and Erie, 1973; Yu *et al.*, 2021). The classification of soil - water capacity occurs based on the soil column's ability to retain water at 100 cm soil depth in between the tensions of o.33 kPa and 15 kPa, or else the entire column if the soil column is shallower. In the study area, 54.60% of the geographical location has less water holding capacity, 19.47% of the study area has low, and 24.05% of the study area has a high water holding capacity.

Soil calcareousness

The range of calcium carbonate in soil indicates the calcareousness in soil. Soil calcareousness is classified into three categories. Those are, category - 0 (non - calcareous), category - 1 (slight calcareous), and category - 2 (strongly calcareous), that are shown in Table 2.

Table 2. Characterisation of Soil calcareousness

Categorizing Unit	Description	Representation in Map (Colour)
0	0- 15% Non-calcareous	Brown
1	15-35 % Slightly calcareous	Green
2	35 -60 % calcareous	Yellow
1000	Water Bodies	Blue

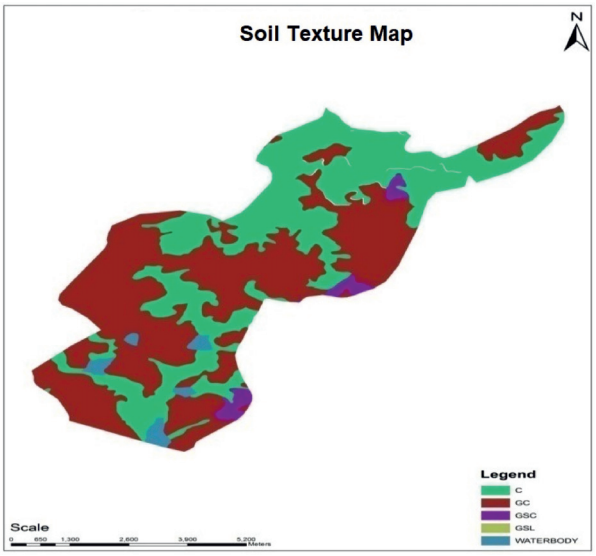

Fig. 3. Soil Texture Map

Remote sensing and GIS tools are used to evaluate several soil samples' characteristics in the study area (Cui *et al.*, 2020). In this study, the field study is united with a comprehensive characterization of the soils. In the study area, 31.54% of the site identified with the absence of soil calcareousness, 32.42% of the area identified with

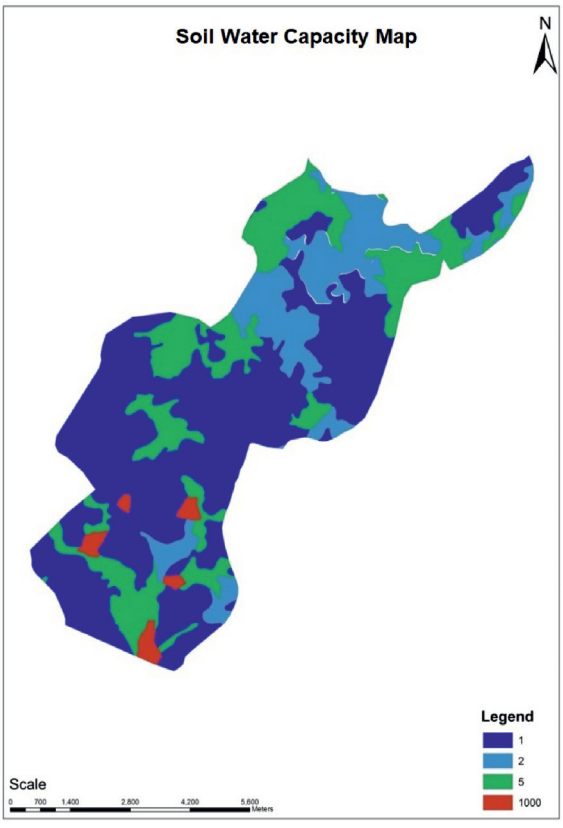

Fig. 4. Soil - water capacity Map

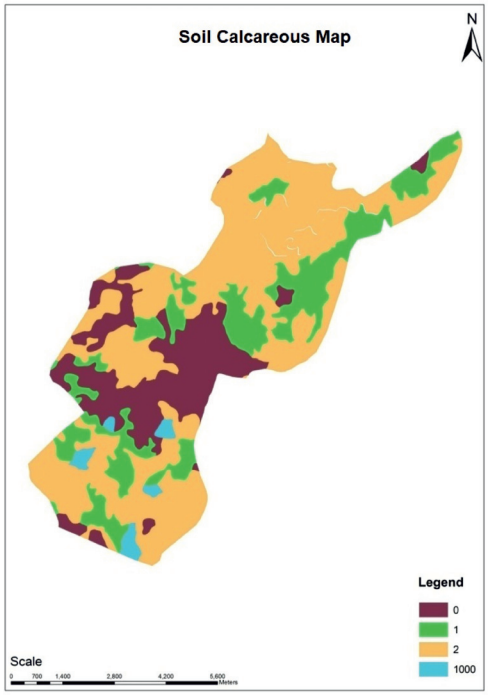

Fig. 5. Soil Calcareous Map

slight soil calcareousness, and 34.14% of the area affected by high soil calcareousness.

A significant feature of calcareousness in the soil is that they mostly build up in stumpy rainfall areas, and these should be appropriately irrigated to be productive. Naturally, improper irrigation water application is the primary cause of many management problems in the agricultural sector (AS Talab *et al.,* 2014). The study area has a moderate to thick laretritic plateau, leading to moderate groundwater potentiality and less soil-water holding capacity. Hence, almost 41% of the study area is left without irrigation in the Kharif season. The water used for irrigation contains more inorganic salts as the water seepage over so many earth materials and dissolves most of these substances due to good dissolution capability. These dissolved substances may accumulate the salts in the soil profile and modify the soil structure. It may also affect the water permeability, which disturbs the plant's growth at a critical level. Management of calcareous soils requires reclamation and improvement methods in the study area as 67% of the study area is identified with slight and high calcareousness.

CONCLUSION

The characterization of soil calcareousness and soil physical and morphological parameters revealed that 54.60% of the study area has a "Clay" type of soil influence, which reduces the water infiltration capacity due to the tight binding of soil components together. It results in less groundwater availability in the study area. This study identified that 54.06% of the study area has less water holding capacity, and 19.47% of the study area has less soil-water holding power. Due to less water availability, 65.84% of the study area's cultivated land is left unirrigated in the Kharif season. The observations showed that 34.14 % of the study area is affected with 35-60% of soil calcareousness, which indicated high calcareousness followed by slight soil calcareousness in 32.42 % of the study area, i.e., 15-35% of calcareousness and 31.54% of the study area is free from calcareousness. This study shows that almost 66% of the study area is affected by calcareousness. A comprehensive physical and morphological analysis is recommended for effective fertilizer application for every cropping pattern concerning calcareous soils. This study also suggests that farmers select plantation and crop varieties that are adaptive to calcareous soils to attain significant crop production. This study further recommends that proper soil calcareous reclamation methods improve land capability and prevent high calcareous soils' conversion into saline soils.

REFERENCES

Taalab, A.S., Ageeb, G.W., Hanan S. Siam and Safaa, A. Mahmoud, 2014. Some Characteristics of Calcareous soils. *A Review-Middle East Journal of Agriculture.* 1 : 875-883.

Chaney, R. C., Slonim, S. M. and Slonim, S. S. 1982. Determination of calcium carbonate content in *soils. Geotechnical properties, behaviour, and performance of calcareous soils. Baltimore, MD: American Society for Testing and Materials.* 3 (15).

Cross, A.T. Young. 2017. Calcareous soil chrono sequences as a model for ecological restoration on alkaline mine tailings. *Sci Total Environ.* 31: 607-608: 168-175. doi: 10.1016/j.scitotenv. 2017. 07.005.

Cui Zou, Zesong Wang, Xianping Cui and Yaser Ostovari, 2020. GIS - based digital modeling of soil infiltration in calcareous soils. *Communications in Soil Science and Plant Analysis.* 51(2).

Ditzler, K. Scheffe, and Monger, H.C. 2017. Soil Science Division Staff. *USDA Handbook 18.* Government Printing Office, Washington D.C.

Jackson, R. and Erie, L. 1973. Soil and Water Management Practices for Calcareous Soils. In: FAO Soils Bulletin 21 - Calcareous Soils. Food and

Agriculture Organization of the United Nations, Rome.

Marsh, M.E. 2003. Regulation of CaCO(3) formation in coccolithophores. *Comp Biochem Physiol B Biochem Mol Biol.* 136(4) : 743-54. doi: 10.1016/s1096-4959(03)00180-5.

M Anji Reddy, Uma Devi Randhi, Santhoshkumar, K. and Vijaya Lakshmi, T. 2013. Land Resources Action plan in Guntur District Using Geographical Information System. *Indian Journal of Applied Research.* 3(3) : 146-148.

Ma, S., Hu, Y., Zeng, Q., Xu, Z., Cui, Y., Ma, Y., Su, J. and Nan, Z. 2021. Temporal changes of calcareous soil properties and their effects on cadmium uptake by wheat under wastewater irrigation for over 50 years. *Chemosphere.* 263 : 127 - 971. doi: 10.1016/j.chemosphere.2020.127971.

Rasha, E.A. 2005. *The relation between active calcium carbonate and some properties of calcareous soils in North Africa.* M. Sc. Thesis Cairo, Univ. of Ins. of African Res. and studies Dep. of Natural Resources.

Sakram Gugulothu, Ratnakar Dhakate, Ksreedhar, A Ramesh and Praveen Raj Saxena, 2020. Geophysical and hydrochemical studies for sustainable development of groundwater resources in northwestern part of Telangana State, India. *J. Earth Syst. Sci.* 129 : 202.

Silvestri, A., Pätzold, J., Fratzl, P., Scheffel, A. and Faivre, D. 2020. Surface-Enhanced Raman Scattering Micro spectroscopy Enables the Direct Characterization of Biomineral - Associated Organic Material on Single Calcareous Micro skeletons. *J Phys Chem Lett.* 15; 11(20) : 8623-8629. doi: 10.1021/acs.jpclett.0c02041.

Song, D., Xi, X., Zheng, Q., Liang, G., Zhou, W. and Wang, X. 2019. Soil nutrient and microbial activity responses to two years after maize straw biochar application in a calcareous soil. *Ecotoxicol Environ Saf.* 180 : 348-356. doi: 10.1016/j.ecoenv.2019.04.073.

Yu, D., Hu, F., Zhang, K., Liu, L. and Li, D. 2021. Available water capacity and organic carbon storage profiles in soils developed from dark brown soil to boggy soil in Changbai Mountains, China. *Soil & Water Res.* 16 : 11"21.