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Influence of soil organic matter on bulk density in Coimbatore soils

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Abstract
Soil organic matter is an important soil property which improves soil structure and overall soil health. Soils rich in organic matter are better in their properties and productivity. Bulk density is an important index for calculating soil quality. Bulk density is a function of soil organic matter. In the present study about 200 soil samples representing different land forms and physiography of Coimbatore have been collected. The samples were analyzed for bulk density and soil organic matter. The data were analyzed to study the effect of soil organic matter on the bulk density of soil as influenced by various land forms. Soil organic matter has got a good relationship with bulk density as evident from increasing soil organic matter decreased the bulk density in Coimbatore soils. Among the different models used to derive the relationship between soil organic carbon and bulk density viz., linear, quadratic and polynomial resulted in a R^2 value of 0.48, 0.6737 and 0.673, respectively. The quadratic model was found to be the best fit with the highest R^2 value and lowest RSE.

Keywords: Soil organic matter, soil organic carbon, bulkdensity, correlation

Introduction
Soil organic matter is an important component of soil solid, constituting 5 % of solid space. Organic matter is the final decomposition product of plant residue, roots and soil organisms. Soil organic matter consists of humic acid, fulvic acid and humin, having different functional groups which play an important role in cation exchange properties. It influences in maintaining the soil structure, moisture retention, nutrient turnover, cation exchange capacity, degradation of pollutants, greenhouse gas emission and soil buffering. Soil organic matter is used as one of the important indices to evaluate soil quality (Gregorich *et al*., 1994) [4]. It improves all the physical properties and supplies all the essential nutrients in the available form to the plants. Soil organic matter (SOM) is the most important component of soil with differing relative importance as the soil type, climate, and land use change. Carbon is a measurable component of soil organic matter. The index for measuring organic matter is by measuring organic carbon using Bemelmans's factor where in; organic carbon = organic matter *1.724. Soil organic carbon is the basis of soil fertility. Soil organic carbon tends to be concentrated in the topsoil. It ranges from 0.5% to 3.0% for most upland.
Bulk density of the soil is the ratio of soil mass to that of bulk volume of the soil. Bulk density is a highly dynamic soil property, which is a function of soil texture and soil organic matter. Bulk density is affected by factors such as water, aeration status, root penetration, clay content, texture, land use and management. It controls the porosity of the soil. It has been studied that bulk density is an important property that can be used to predict the concentration and flow of nutrients in the soil (Bernoux *et al.*, 1998) [2]. The normal range of bulk densities for clay is 1.0 to 1.6 mg/m^3 and a normal range for sand is 1.2 to 1.8 mg/m^3 with potential root restriction occurring at ≥ 1.4 mg/m^3 for clay and ≥1.6 mg/m^3 for sand (Aubertin *et al*., 1965) [1].
Bulk density varies inversely with respect to soil organic matter content *i.e*., higher the organic matter content lower will be the bulk density (Leifeld *et al*., 2005) [6]. The aim of the study is to determine the extent of correlation between soil organic matter and bulk density in Coimbatore soils and to find the best model that can predict the same.

Materials and Methods
Coimbatore lies at 11°0′19.98″N 76°57′58.03″E in south India at 411 meters (1349 ft) above sea level on the banks of the Noyyal River, in southwestern Tamil Nadu. It covers an area of

4723 Km^2 (247.92 sq mi). It is surrounded by the Western Ghats mountain range in the West and the North, with reserve forests of the Nilgiri Biosphere Reserve on the northern side.

The mean maximum and minimum temperatures vary between 39.6 °C and 17.3 °C and the highest temperature ever recorded is 41 °C and the lowest is 12°C. On an average, the district gets 695 mm of rainfall in a year. Coimbatore receives high rainfall from North East Monsoon followed by South West Monsoon. The geology of the area mainly comprises of crystalline rocks of Archean and Pre-Cambrian age and some parts with recent alluvium of Quaternary age.

The soil sampling is done by Random sampling method. The sampling points that fall under different physiography of Coimbatore were identified using Global Position System. Using an auger, soil from the top (0-15 cm) was collected and labeled. Around 200 samples were collected from different physiography excluding township and dense forests.

The collected samples were air-dried, grounded and sieved through 2mm sieve to measure bulk density. Bulk density was determined using cylinder method. For the estimation of Soil organic carbon the processed samples were sieved through 0.5mm sieve for organic carbon analysis. Soil organic carbon was determined by chromic acid wet digestion method. The soil organic carbon values were converted to soil organic matter by Bemelmans's factor (1.724*SOC).

Correlation between soil organic matter and bulk density was analyzed using SPSS 2000. Linear model, Quadratic model and polynomial models (Table 1) were used to find the relationship between bulk density and soil organic matter. The statistical tool used for the same was R studio Version 1.1.463-© 2009-2018.

Table 1: Model equations

Linear model	$y = ax + b$
Quadratic model	$y=ax^2+bx+c$
Polynomial model	$y=ax^3+bx^2+c$

Results and Discussions

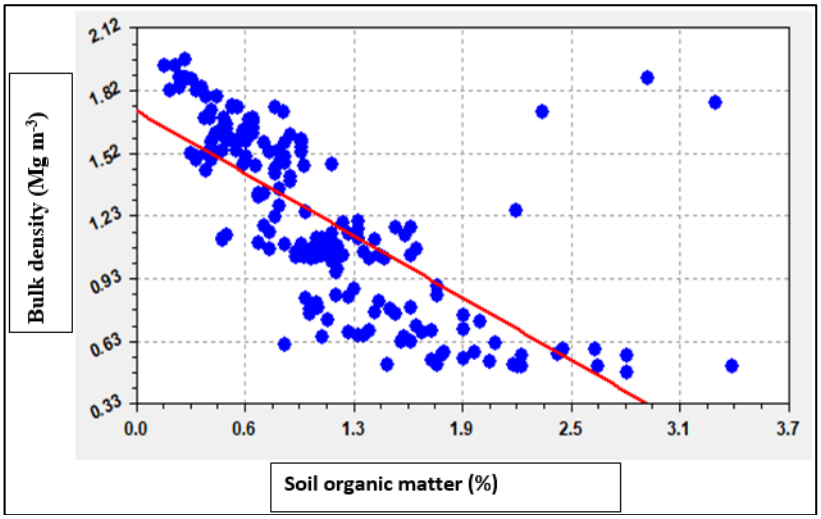
The correlation between bulk density and soil organic matter in Coimbatore soils have shown a negative relationship with r= - 0.69 (Table. 2). It indicates that bulk density is lower if the soil is higher in organic matter. Soils become more friable, porous and chemically active if rich in organic matter which tend to make soil lower in bulk density. Similar results were obtained by Prevost (2004), (Federer *et al.*, 1993) [3], (Sakin *et al.*, 2011) [9] and (Mestdagh *et al.*, 2006) [7] indicating the negative correlation between bulk density and soil organic matter is universal. The mean Bulk density and soil organic matter was found to be 1.22 and 1.06 with a standard error of 0.42 & 0.61, respectively.

Table 2: Correlation between bulk density and soil organic carbon

	BD	SOM
BD	1	-0.698**
SOM	-0.698**	1

Three models were studied namely linear, polynomial and quadratic models (Table 3). Out of all the models quadratic model has the highest R^2 value (R^2=0.673) and lowest residual standard error value (RSE= 0.242). Hence, the quadratic model is found to be the best fit model for establishing the relationship between bulk density and soil organic matter of Coimbatore soils (Fig 2). Polynomial model is found to be the next best fit with R^2=0.668 and residual standard error value of 0.243 which is almost comparable with quadratic model (Fig 3). The linear model gave lowest R^2 value (R^2=0.484) and highest residual standard error value (RSE=0.303) (Fig 1). Non-linear models performed better than the linear model.

It can be concluded soil organic matter has got a good relationship with bulk density as evident from increasing soil organic matter decreased the bulk density in Coimbatore soils. Non-linear models can be used for establishing relationship between bulk density and soil organic matter. Similar results were obtained by Curtis and Post, 1964, (Federer *et al.*, 1993) [3] and (Huntington *et al.*, 1989) [5].

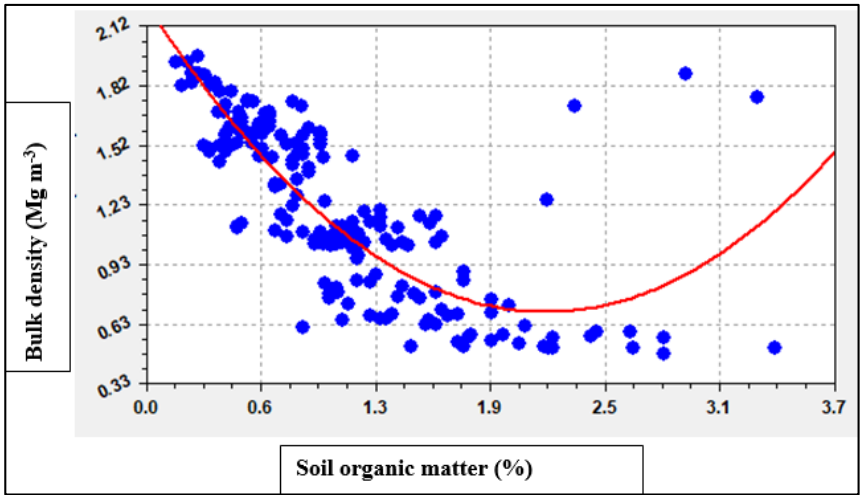


Linear model equation: **BD = 1.73-0.47 SOM**
(BD= Bulk density; SOM=Soil organic carbon)

Fig 1: Linear model scatter plot between bulk density and soil organic matter

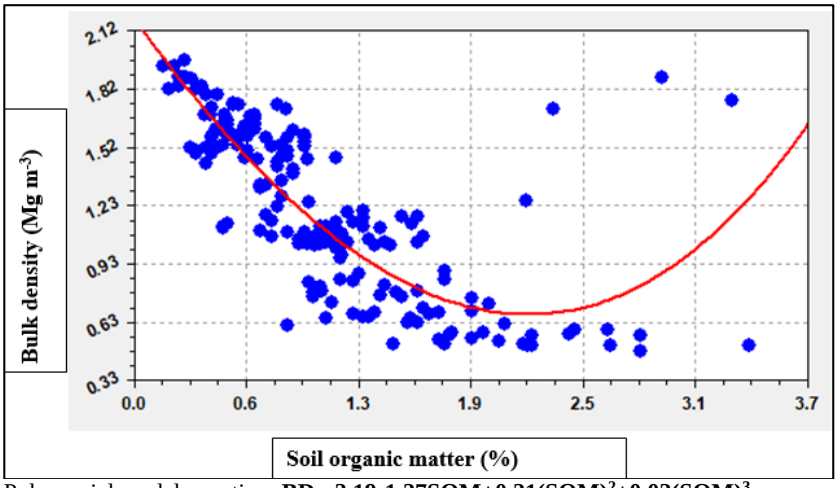
Table 3: Statistical analysis data

	Model Coefficients			Multiple R^2	Adjusted R^2	Residual standard error
Linear model		Estimate	Std. Error	0.486	0.484	0.303
	Intercept	1.73261	0.04277			
	Soil organic matter	-0.47684	0.03481			
Quadratic model		Estimate	Std. Error	0.673	0.699	0.242
	Intercept	2.25226	0.05979			
	Soil organic matter	-1.43213	0.09434			
	Soil organic matter^2	0.32843	0.03099			
Polynomial model		Estimate	Std. Error	0.673	0.668	0.243
	Intercept	2.19953	0.09951			
	Soil organic matter	-1.27940	0.24886			
	Soil organic matter^2	0.21325	0.17637			
	soilorganicmatter^3	0.02372	0.03575			



Quadratic model equation: BD = 2.25-1.43SOM+0.32(SOM)2

Fig 2: Quadratic model scatter plot between bulk density and soil organic matter



Polynomial model equation: **BD= 2.19-1.27SOM+0.21(SOM)^2+0.02(SOM)^3**

Fig 3: Polynomial model scatter plot between bulk density and soil organic matter

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