International Research Journal of Earth Sciences ISSN 2321–2527
Vol. **4(1),** 1-6, January **(2016)** *Int. Res. J. Earth Sci.*

Relation of Soil bulk Density with Texture, Total organic matter content and Porosity in the Soils of Kandi Area of Kashmir valley, India

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Available online at: www.isca.in, www.isca.me
Received 24th February 2015, revised 12th October 2015, accepted 5th December 2015

Abstract

Bulk density is a function of soil texture, mineral density of soil (sand, silt, and clay) and organic matter particle as well as their packing arrangement. The present study is intended at examining the relationship between bulk density, texture (clay content and fine sand content), organic matter content and porosity in the soils of Kandi areas in Kashmir valley. Twenty five surface soil samples were collected from different locations of the study area at a depth of 20-35 cms. Soil bulk density showed negative correlation with Clay, total organic matter content and porosity except with sand content (S).

Keywords: Bulk density, Texture, organic matter, Porosity, Kandi Area.

Introduction

Bulk density is affected by factors such as water, aeration status, root penetration, clay content, texture, land use and management. Therefore, it is a very important soil parameter[1]. One of the soil properties necessary to predict the change, flow and concentration of nutrients in the soils is bulk density[2]. Amount of organic matter in soils, texture, mineral composition and porosity are dominating factors affecting bulk density and managing soils scientifically requires a proper knowledge of bulk density[3]. Bulk density values are required to calculate soil porosi[4]. Soil organic matter (SOM) is the most important component of soils with differing relative importance as the soil type, climate, and land use change. OM in soil acts as a source of nutrients. OM in soils is the key element responsible for a host of biological activities including immobilization and release of nutrients. SOM is closely associated with sustainable land management but there is a great deal of variation in perspectives on the roles of SOM between different stakeholders. Still people use SOM as a dumping ground for excess nutrients and toxins, or as a convenient store for fossil fuel emissions, particularly CO_2. Farmers are in a dire need of sustainable land management systems for maintaining OM and nutrient reserves[5].

Study Area: The Valley of Kashmir, situated in the complexity of great north-western Himalayan, is a longitudinal depression making it more vulnerable to the accelerated process soil erosion. It is undoubtedly a synclinal trough. The Valley has a tectonic origin and bears a strong geological and geographic relationship with the Himalayan formations. Administratively, Kashmir valley is the most populated Division of the state of Jammu and Kashmir. It lies between 33° 25' to 34° 50' N latitude and 74° to 75° 50' E longitude and is roughly 135 km long and 114 km wide enclosing an area of about 15853 sq.km. The average altitude of the Valley is about 1800 m while some peaks exceed the height of 4000 m from mean sea level[6]. Kandi refers to an area which is upland or sub montane having scarcity of water, undulating topography, steep and irregular slopes, erodible and low water retentive soils with terrain dissected by numerous gullies[7]. The problems which the area is mostly suffering from are problems of soil erosion, irrigation, communication, industries, drinking water and various amenities and facilities of life[8]. Economically, this is the most underdeveloped part of the state in which a substantial proportion of population (40%) is living below the poverty line[9]. Known for being backward amidst prosperous agrarian state of Punjab, the Kandi belts face the hex of degraded soil, water and other natural resources[10]. Although rainfall is generally higher in the mountainous areas, they have problems of accessibility and marginalized poor communities.

A region consisting of geographical elements of varying nature like steep slopes, terraced croplands, sloping rangelands and scattered patches of shrubs and trees forms a complex landscape. Rainfall is the only source of irrigation in the region. Wadis, dissecting the mountains, are the areas of irrigation agriculture. Water erosion is the main cause of land degradation in these areas[11]. Kandi areas cover around 10 percent of the total geographical area of Kashmir valley (Figure-1). These are mostly found on the west side of the valley covering mountain foothills and sloping Karewas where there is undulating topography with scarcity of water and irrigation facilities (Figure- 2).

Materials and Methods

The paper was aimed at determining the bulk density. The relationship between bulk density and soil particle distribution, organic matter and porosity of soil in Kandi areas of Kashmir valley, was drawn statistically. A total of 25 Soil samples were collected from different locations at the depth of 20-35cm across the study area. To collect a sample, five pits were dug. About 1 kg of composite sample was taken from each soil sample through standard procedures. The soils were allowed to dry in shade for 1 hour. Different physio-chemical properties of soils were analysed using standard procedures.

Organic Matter (OM) was obtained from estimated organic carbon (OC) using the conventional conversion[12].
OM = 1.72 × OC

The soil bulk density is a dependent variable having a definite statistical relationship with soil texture, organic matter and porosity. Higher porosity is found in clay soils than sandy soils. However, the relationship between texture and bulk density does not show a strong bond and depends on a multitude of factors such as organic matter content and soil profile depth. Bulk density is closely related to the soil porosity through the following relationship[13].

$$n = 1 - (db / dp)$$

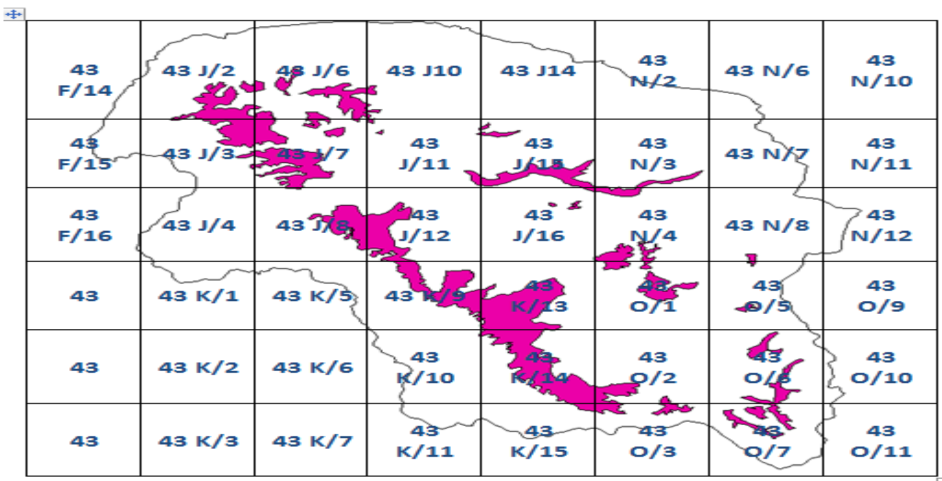
Where, n = porosity; db = bulk density and dp = particle density

Statistical analysis: The relationship between different soil parameters and nutrient content of soils was determined using correlation coefficient "r".

$$r = n\sum xy - (\sum x)(\sum y) / n\sum x^2 - (\sum x)2n(\sum y^2) - (\sum y)2$$

Where: n is the number of pairs of data (x, y)

Table-2 shows the Correlation Coefficients (r) between soil parameters and bulk density.



Source: survey of India Toposheets (1961)

Figure-1
Representation of Kandi areas along with Toposheet numbers

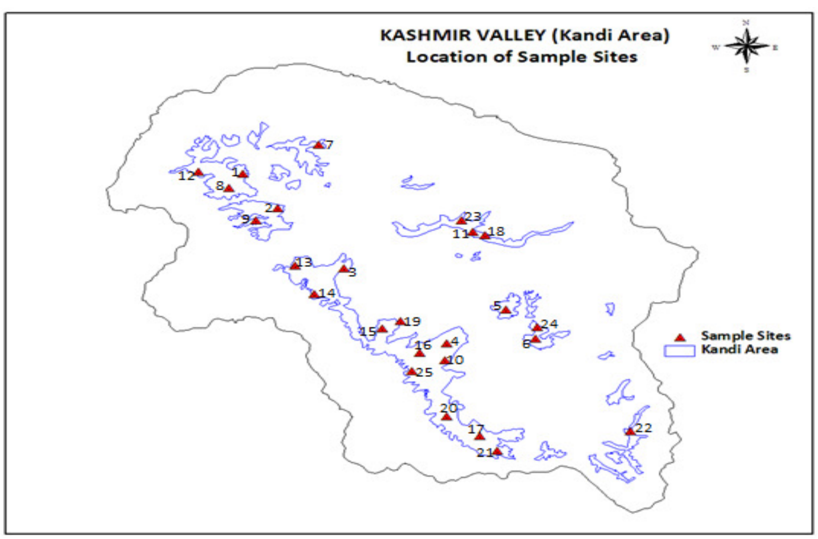


Figure-2
Map of Study Area

Results and Discussion

The sand, silt and clay content in collected samples ranges 49.07 – 75.64, 12 - 34 and 6 – 25 % respectively and these soils were categorized as sandy clay loam, loamy sand, sandy loam and loam. Since in each soil sample there was higher percentage of sand and silt, most of them were falling in the categories of loamy sand and sandy loam. Out of 25 soil samples 3 fall in sandy clay loam and 3 in loam categories as given in Table-1.

Sand content has a profound effect on soil bulk density than other soil properties. Sand content has shown a positive correlation with the soil bulk density (r = 0.60) (Figure-3) while as clay content is negatively correlated with bulk density (r = -0.41) of soil samples (Figure-4). The bulk density is a proxy measure of soil porosity. Also, a significant negative correlation (r = - 0.67) was found between porosity and bulk density of soil samples (Figure-5).

Table-1
Texture, Textural class, Organic carbon, Total organic matter, Bulk density and Porosity of soil samples

Sample No.	Texture (%)				Textural class	Organic Carbon %	Total organic matter %	Bulk density db(gm/cm^3)	Porosity 100-(db/dp*100)
	Coarse sand	Sand	Silt	Clay					
1.	1.04	68.96	12	18	Loamy sand	0.49	0.84	1.46	43.85
2.	0.10	57.9	28	14	Sandy loam	0.56	0.97	1.34	48.26
3.	0.50	49.5	30	20	Loam	0.77	1.32	1.27	52.79
4.	1.25	68.75	16	24	Sandy clay loam	0.86	1.47	1.28	51.52
5.	0.30	54.7	25	20	Sandy clay loam	0.61	1.05	1.35	48.28
6.	1.75	63.25	28	19	Sandy loam	0.70	1.21	1.25	51.17
7.	1.5	58.5	30	10	Sandy loam	0.59	1.02	1.32	42.86
8.	0.56	59.44	24	16	Sandy loam	0.42	0.72	1.33	45.71
9.	3.11	56.89	23	20	Sandy loam	0.39	1.25	1.23	47.89
10.	0.14	53.86	26	20	Sandy clay loam	0.57	0.99	1.32	49.62
11.	0.34	49.66	30	20	Loam	1.39	2.4	1.13	57.36
12.	1.7	55.83	34	10	Sandy loam	0.78	1.64	1.24	51.18
13.	1.1	58.86	25	20	Sandy Loam	1.07	1.84	1.20	54.72
14.	6.42	65.58	22	6	Loamy sand	0.52	0.9	1.43	36.44
15.	0.96	55.04	34	14	Sandy loam	0.57	0.98	1.32	48.64
16.	0.32	57.68	32	14	Sandy Loam	0.78	1.34	1.27	46.63
17.	0.35	59.65	25	15	Sandy Loam	1.08	1.86	1.25	49.19
18.	0.66	55.34	34	25	Sandy loam	0.79	1.36	1.23	54.78
19.	1.16	54.84	26	18	Sandy Loam	0.93	1.6	1.20	54.55
20.	1.45	58.25	24	16	Sandy loam	0.97	1.67	1.29	42.92
21.	0.14	62.86	28	10	Loamy Sand	1.34	2.31	1.19	49.58
22.	0.36	75.64	14	10	Loamy sand	0.55	0.95	1.41	32.86
23.	0.30	49.07	34	16	Loam	1.41	2.43	1.16	53.97
24.	1.20	58.8	30	19	Sandy Loam	1.56	2.69	1.12	56.08
25.	0.46	65.54	24	16	Loamy Sand	0.57	2.46	1.30	56.18

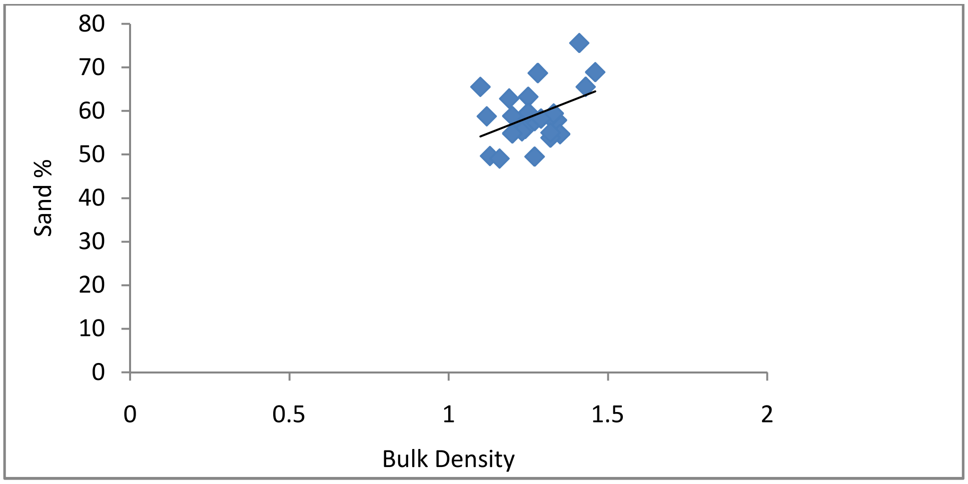


Figure-3
Correlation between sand content and bulk density

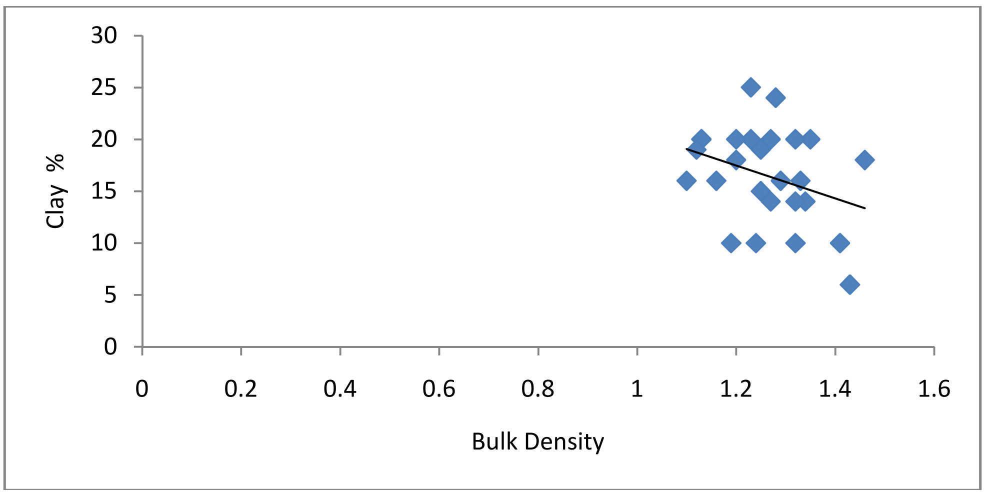


Figure-4
Correlation between clay content and bulk density

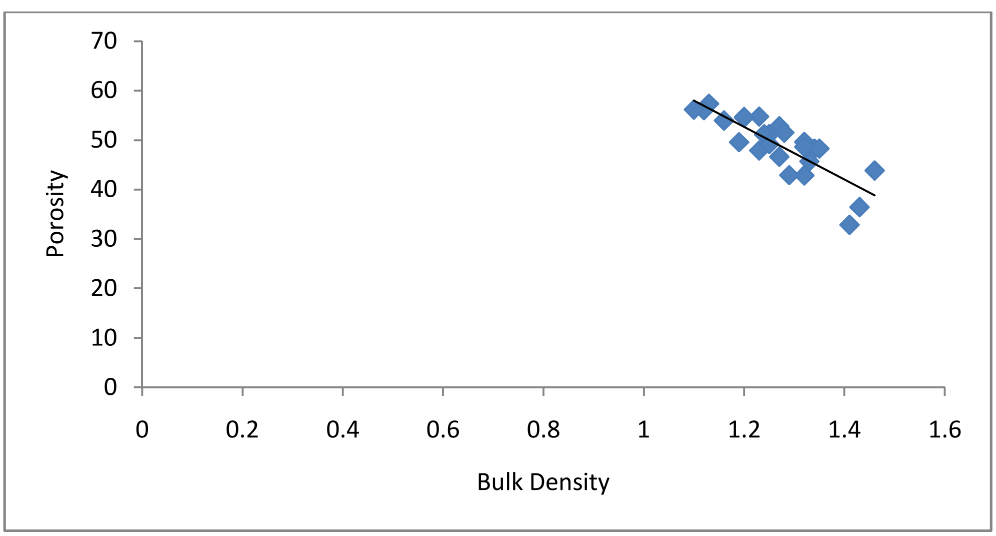


Figure-5
Correlation between porosity and bulk density

Due to higher percentage of sand and silt, bulk density and porosity of soil samples ranges from 1.12 – 1.46 g m^{-3} and 32.86 – 57.36 respectively.

A conversion factor of 1.72 is commonly used to convert organic carbon to organic matter. Organic carbon and total organic matter content of soil samples varied from 0.39 – 1.56 % and 0.72 – 2.69% respectively. The sand content is positively correlated with bulk density (0.60). Clay content and porosity has a significant negative correlation with bulk density as shown in Table-2.

The results show a strong negative correlation (r = - 0.75) between organic matter and bulk density of soil samples (Figure-6).

Thus, the study indicates that as the organic matter increases the bulk density of soil decreases which is required for the proper growth of the plants.

Conclusion

So far as the Kandi areas of Kashmir valley are concerned, the soils were found to be less productive. As the bulk density of soil is higher, the porosity is lower and subsequently water holding capacity of soil is also low. It also affects root growth as well as other soil properties of the soil. There is a significant negative correlation between organic matter and bulk density of soil. Soil productivity is largely a function of amount of organic matter present6 in the soil. It is one of the important components of soil from production point of view and helps the soil to maintain better aeration for germinating seeds and plant root development. All the soil samples were having low organic matter content which means lower nutrient status, low water holding capacity and thus low soil productivity as well.

Table-2
Correlation coefficient and Level of significance among some soil properties

Soil related properties	Correlation Coefficient (r)	Level of Significance
Bulk density – Sand (%)	0.60	Significant positive
Bulk density – Clay (%)	-0.41	Significant negative
Bulk density – Total organic matter	-0.75	Strong negative
Bulk density – Porosity	-0.52	Significant negative

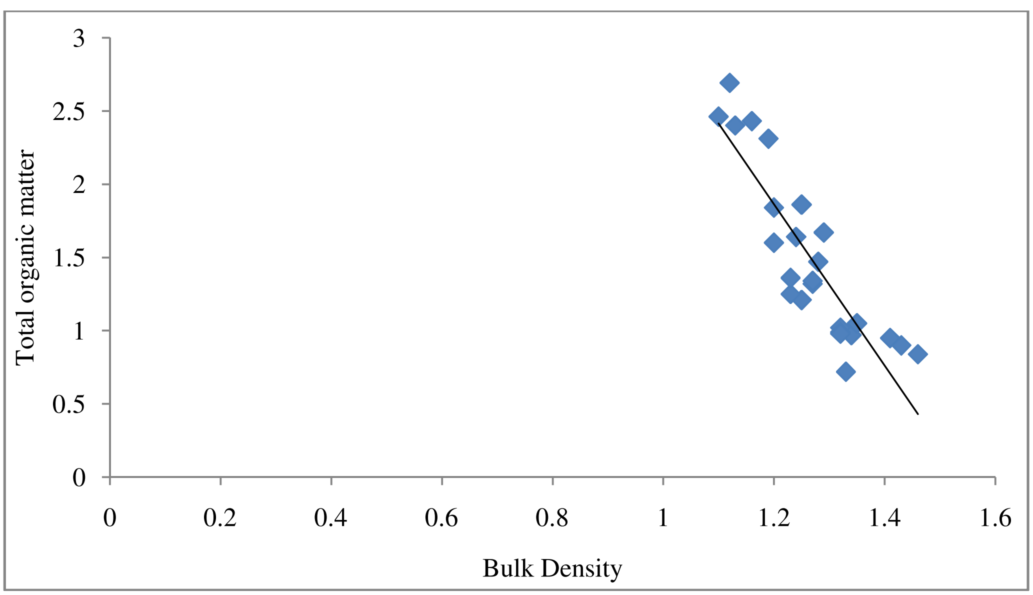


Figure 6
Correlation between total organic matter and bulk density

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