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Evaluation of soil health and soil quality analysis of different blocks of Bundi district, Rajasthan, India

Banwari Lal Meena, Tarence Thomas and Narendra Swaroop

Abstract
Agricultural intensification is placing tremendous pressure on the soil's capacity to maintain its functions leading to large-scale ecosystem degradation and loss of productivity in the long term. Therefore, there is an urgent need to find early indicators of soil health degradation in response to agricultural management. Soil quality is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in the context of sustainable agricultural production. Soil physico-chemical parameters are more important that control its quality. In this study, morphological and all physical properties of soil with their spatial variability in different blocks of Bundi district in Rajasthan was conducted. It was concluded that the colour was changing with the sites. The textural classes identified were clay and clay loam. The bulk density of soil varied from 1.16 to 1.50 Mg m^{-3}. The particle density of soil varied from 2.28 to 2.92 Mg m^{-3}. The percent pore space of soil ranged from 42.96 to 54.83%. The specific gravity ranged from 1.97 to 2.25. The water holding capacity of soil varied from 47.98 to 62.13% and maximum mean water holding capacity was found in Gambhira (V_2) (62.13%). We concluded that the soil parameters were studied during the course of investigation responded good physical properties. The judicious use of organic manure in combination with inorganic fertilizers not only paves the way for achieving sustainable yields of crops but also maintains health of our finite soil without deterioration for future generations.

Keywords: soil health, soil quality, physical properties, Bundi, Rajasthan, soil, etc.

Introduction

"The soil is a natural body of mineral and organic constituents, differentiated into horizons of variable depth, which differs from the material below in morphology, physical makeup, chemical properties and composition, and biological characteristics" (Joffe, 1949). "Dokuchaev defined soil as an independent natural body developed over time under the influence of five soil-forming factors: parent rock, living organisms, climate, relief and time" (Dokuchaev, 1948). "Soil is more or less a loose and crumby part of the outer earth crust in which, by means of their roots, plants may or do find foot hold and nourishment as well as other conditions essential to their growth" (Hilgard, 1892).

The history of Agriculture in India dates back to Indus Valley Civilization and even before that in some places of Southern India [Brese, White (1993)] [4]. Agriculture is one of the world's most important activities supporting human life. Potential land use assessment is likely to the prediction of land potential for productive land use type (Dadhwal *et al.*, 2011) [6]. Land productivity capacity or land quality is a comprehension, at the same time a precise concept in terms of agricultural activities (Dengiz and Saglam, 2012) [8]. Agricultural intensification and massive infrastructure development in the recent years without considering the variability of entire production system enhances the risk of soil erosion and fertility depletion (Singh *et al.*, 2007) [24]. Soil is a component of the lithosphere and biosphere system. It is a vast natural resource on which the life supporting systems and socio-economic development depends. Organic matter is one of the most important constituents of soil, a good amount of organic carbon / matter in soil increase soil fertility. The core constraints in relation to land use include depletion of organic carbon, soil micronutrients and macronutrients, removal of top soil by erosion, change of physical properties and increased soil salinity (Kumar *et al.*, 2017) [11].

Geographically, Rajasthan is located between 23˚ 3ˈ to 30˚ 12ˈ North latitude and 69˚ 30ˈ to 78˚ 17ˈ East longitude, with the tropic of cancer passing through the southernmost tip of the state. The climate of Rajasthan plain is characterized by extremely high range of temperature and aridity although sharing the monsoonal variations throughout the year it is the hottest region of

India (mean June temperature 34.5 °C at Jaisalmer and Bikaner) with annual range of temperature between 14° to 17 °C. The rainfall is very low, highly erratic and variable seasonally. Average rainfall of Rajasthan is 52.26 cm with high degree of regional and temporal variability. The climate of Rajasthan state has varied contrasts and the presence of Aravallis is the greatest influencing factor. The state can broadly be divided into Arid, Semi-Arid and Sub-Humid Regions, on the basis of rainfall intensities. The Western Rajasthan i.e. in the arid region consist of the districts of Hanumangarh, Jaisalmer, Barmer, Ganganagar, Churu, Jhunjhunu, Sikar, Nagaur, Jodhpur, Pali and Jalore covering an area of nearly 1,43,842 square kilometres. The region is characterized by low and highly variable rainfall years creating inhospitable living condition to both human and livestock population. An area of 9,290 square kilometres in extreme western parts of the state has true desert conditions. With an improvement in rainfall pattern from the west towards the east Rajasthan semi-arid conditions are created in area of about 66,830 square kilometres in the districts of Alwar, Jaipur, Bharatpur, Ajmer, Tonk, Sawai Madhopur, Bhilwara, Bundi, Kota, Chittorgarh, Udaipur, Sirohi, Dungarpur and parts of Jhalawar and Banswara.

The soils of the Bundi district can be broadly classified as the Deep Brown Loamy, Deep Brown Clayey, Medium Brown Loamy, Shallow Yellowish Brown Gravelly Loamy, Deep Black Clayey and Red Gravelly Loam Hilly soils. Under the new system, most soils of Rajasthan belong to only 5 orders- Aridisols, Alfisols, Entisols, Inceptisols and Vertisols (District Profile, KVK). Bundi is a district of Rajasthan. Bundi is located between 25˚25'57.3132" N and 75˚38'53.7828" E. It has an average elevation of 268 meters (879 feet) from sea level. The district has an area of 5,550 square kilometres. The climate of the district is extremely hot in the summers and fairly cold in the winters. The average annual temperature is 26.5˚C in Bundi. The average annual rainfall of the region is 772 mm (District Factbook, 2019) [10].

The term "soil health" originates in the observation that soil quality influences the health of animals and humans via the quality of crops (Warkentin, 1995) [28]. "Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans." According to Moebius-Clune *et al.* (2016) [16] a conceptual difference between the two terms may be that soil quality comprises both inherent and dynamic properties, whereas soil health is focused on the dynamic properties. The term "soil fertility" is often used as a synonym to the term "soil quality". Indeed, the definition of Mader *et al.* (2002) [20] that a fertile soil "provides essential nutrients for crop plant growth, supports a diverse and active biotic community, exhibits a typical soil structure, and allows for an undisturbed decomposition" went beyond the provision of yields. In line with this, the maintenance of "natural soil fertility" is at the heart of organic farming (Rusch, 1985) [21]. The concept of soil quality as introduced by Larson and Pierce (1991) [14] and Doran and Parkin (1994) [7] was heavily criticized in a series of papers (Letey *et al.*, 2003; Sojka & Upchurch, 1999; Sojka *et al.*, 2003) [15, 22, 23] for being subjective and ill-defined. A particular recommendation was to speak of soil use rather than soil functions, so that the responsibility to maintain the quality of the soil can be clearly assigned to the user of the soil. In particular, it was claimed to raise awareness and enhance communication between various stakeholders regarding the importance of soil resources (Karlen *et al.*, 2001) [29].

According to USDA soil quality indicators are classified into four categories that include visual, physical, chemical and biological indicators. The physical indicators are related to the organization of the particles and pores, reflecting effects on root growth, speed of plant emergence and water infiltration; they include depth, bulk density, porosity, aggregate stability, texture and compaction. Chemical indicators include pH, salinity, organic matter content, phosphorus availability, cation exchange capacity, nutrient cycling and the presence of contaminants such as heavy metals, organic compounds, radioactive substances, etc. These indicators determine the presence of soil-plant-related organisms, nutrient availability, water for plants and other organisms and mobility of contaminants. Finally, biological indicators include measurements of micro and macro-organisms, their activities or functions. Concentration or population of earthworms, nematodes, termites, ants, as well as microbial biomass, fungi, actinomycetes, or lichens can be used as indicators, because of their role in soil development and conservation; nutrient cycling and specific soil fertility (Anderson, 2003). Biological indicators also include metabolic processes such as respiration, used to measure microbial activity related to decomposition of organic matter in soil (Bastida *et al.*, 2008) [2].

Materials and Methods

The present study entitled "Evaluation of Soil Health and Soil Quality Analysis of Different Blocks of Bundi District, Rajasthan, India" was conducted during the 2019-20 in three stages *i.e.* soil survey and mapping, collection of samples and their analysis for different soil parameters.

Site details

Bundi district is the south-east region of Rajasthan, from where the soil has been taken for analysis. Bundi is located between 25˚25'57.3132" N and 75˚38'53.7828" E. It has an average elevation of 268 meters (879 feet) from sea level. The district has an area of 5,550 square kilometres. The climate of the district is extremely hot in the summers and fairly cold in the winters. The average annual temperature is 26.5˚C in Bundi. The average annual rainfall of the region is 772 mm (District Factbook, 2019) [10]. The soils of the Bundi district can be broadly classified as the Deep Brown Loamy, Deep Brown Clayey, Medium Brown Loamy, Shallow Yellowish Brown Gravelly Loamy, Deep Black Clayey and Red Gravelly Loam Hilly soils (District Profile, KVK).

Soil Sampling

Soil samples were collected from the three different blocks of Bundi district Rajasthan. They are Nainwan, Karwar and Indergarh. Soil samples were collected with the help of Khurpi, Spade and meter scale. In each block three village selected for sampling and samples obtained from two different depths 0-15 cm and 15-30 cm, totally eighteen soil sample were collected.

Table 1: Soil physical properties and their respective methods for analysis

S. No.	Parameters	Unit	Methodology	Author's
1.	Soil texture	%	Bouyoucos Hydrometer	Bouyoucos, 1927 [3]
2.	Soil colour	-	Munsell Soil Colour Chart	Annonymous, 1971
3.	Particle density	Mg m^{-3}	Relative Density Bottle	Muthuaval *et al.*, 1992 [17]
4.	Bulk density	Mg m^{-3}	100 ml Graduated Measuring Cylinder	Muthuaval *et al.*, 1992 [17]
5.	Pore space	%	%TPS = 100 - %SS	Muthuaval *et al.*, 1992 [17]
6.	Water holding capacity	%	100 ml Graduated Measuring Cylinder	Muthuaval *et al.*, 1992 [17]
7.	Specific gravity	-	Pycnometer/Relative Density Bottle	-

Results and Discussion

Morphological characteristics of soil

Soil colour (Dry method)

At depth 0-15 cm the soil colour

Grayish brown was found in the village of Kashpuriya (V_1) and Manpura (V_3) and Brown was found at the village of Gambhira (V_2), Mani (V_5) and Kashipura (V_6) and Pale brown was found in the village of Karwar (V_4) and Strong brown was found at the village of Jainiwas (V_7) and Light olive brown was found in the village of Ramajpura (V_8) and Light yellowish brown was found at the village of Babai (V_9).

At depth 15-30 cm the soil colour

Gray was found at the village of Kashpuriya (V_1) and Manpura (V_3) and Grayish brown was found in the village of Gambhira (V_2) and Olive brown was found at the village of Karwar (V_4) and Brown was found in the village of Mani (V_5), Kashipura (V_6) and Ramajpura (V_8) and Olive yellow was found at the village of Jainiwas (V_7) and Babai (V_9). Similar results were reported by Mehta *et al.*, (2012) [18].

Soil colour (Wet method)

At depth 0-15 cm the soil colour

Very dark grayish brown was found in the village of Kashpuriya (V_1) and Gambhira (V_2) and Very dark gray was found at the village of Manpura (V_3) and Dark grayish brown was found in the village of Karwar (V_4), Mani (V_5) and Kashipura (V_6) and Brown was found at the village of Jainiwas (V_7) and Dark brown was found in the village of Ramajpura (V_8) and Light olive brown was found at the village of Babai (V_9).

At depth 15-30 cm the soil colour

Very dark grayish brown was found in the village of Kashpuriya (V_1), Gambhira (V_2) and Ramajpura (V_8) and Gray was found at the village of Manpura (V_3) and Dark grayish brown was found in the village of Karwar (V_4), Mani (V_5) and Kashipura (V_6) and Light olive brown was found in the village of Jainiwas (V_7) and Babai (V_9). Similar results were reported by Mehta *et al.*, (2012) [18].

Physical properties of soil

Soil Texture (Sand, Silt and Clay %)

The soil texture - clay was found in both two depths (0-15 cm and 15-30 cm) of villages, Kashpuriya (V_1), Gambhira (V_2), Manpura (V_3), Karwar (V_4), Mani (V_5), Kashipura (V_6) and soil texture - clay loam was found in both depths (0-15 cm and 15-30 cm) of villages, Jainiwas (V_7), Ramajpura (V_8) and Babai (V_9). The sand, silt and clay percentage varied from 30.08-46.74%, 19.28-28.48% and 25.48-50.58% respectively. Similar results were reported by Mehta *et al.*, (2012) [18] and Meena *et al.*, (2017) [19].

Bulk density (Mg m^{-3})

In soil depth the highest mean bulk density was found at 15-30 cm (1.38 Mg m^{-3}) which is significantly higher than 0-15 cm (1.26 Mg m^{-3}). In villages the maximum mean bulk density was found in Jainiwas (V_7) (1.50 Mg m^{-3}) and minimum mean bulk density was found in Gambhira (V_2) (1.16 Mg m^{-3}). The high organic matter content lowers the bulk density, whereas compaction increases the bulk density. The bulk density increases with increase in soil depth. Similar results were reported by Meena *et al.*, (2017) [19] and Urmila *et al.*, (2018) [27].

Particle density (Mg m^{-3})

In soil depth the highest mean particle density was found at 15-30 cm (2.67 Mg m^{-3}) which is significantly higher than 0-15 cm (2.59 Mg m^{-3}). In villages the maximum mean particle density was found in Manpura (V_3) (2.92 Mg m^{-3}) and minimum mean particle density was found in Kashpuriya (V_1) (2.28 Mg m^{-3}). Particle density increases with increase in depth. Particle density is the density of soil particles alone. Particle density is dependent on the mineral composition of the soil. Particle density is higher than bulk density. Similar results were reported by Meena *et al.*, (2017) [19] and Urmila *et al.*, (2018) [27].

Pore space (%)

In soil depth the highest mean pore space was found at 0-15 cm (51.2%) which is significantly higher than 15-30 cm (48.35%). In villages the maximum mean pore space was found in Manpura (V_3) (54.83%) and minimum mean pore space was found in Jainiwas (V_7) (42.96%). The pore space (%) decreases abruptly with increase in depth. Similar results were reported by Meena *et al.*, (2017) [19] and Urmila *et al.*, (2018) [27].

Specific Gravity

In soil depth the highest mean specific gravity was found at 15-30 cm (2.21) which is significantly higher than 0-15 cm (2.07). In villages the maximum mean specific gravity was found in Gambhira (V_2) (2.25) and minimum mean specific gravity was found in Kashpuriya (V_1) (1.97). Similar results were reported by Sahu and David (2014) [25].

Water holding capacity (%)

In soil depth the highest mean water holding capacity was found at 0-15 cm (57.53%) which is significantly higher than 15-30 cm (52.85%). In villages the maximum mean water holding capacity was found in Gambhira (V_2) (62.13%) and minimum mean water holding capacity was found in Jainiwas (V_7) (47.98%). These variations were due to clay, silt and organic carbon content and low WHC in sandy soils due to high sand and less clay content. Similar results were reported by Kadu *et al.*, (2009) [13].

Table 2: Morphological characteristic of soil of different villages of Bundi district, Rajasthan.

Villages	Soil colour in dry condition		Soil colour in wet condition	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Kashpuriya (V_1)	10YR, 5/2 Grayish brown	10YR, 5/1 Gray	10YR, 3/2 Very dark grayish brown	10YR, 3/2 Very dark grayish brown
Gambhira (V_2)	10YR, 5/3 Brown	2.5Y, 5/2 Grayish brown	2.5Y, 3/2 Very dark grayish brown	2.5Y, 3/2 Very dark grayish brown
Manpura (V_3)	2.5Y, 5/2 Grayish brown	10YR, 5/1 Gray	10YR, 3/1 Very dark gray	10YR, 5/1 Gray
Karwar (V_4)	10YR, 6/3 Pale brown	2.5Y, 4/4 Olive brown	10YR, 4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Mani (V_5)	10YR, 5/3 Brown	10YR, 5/3 Brown	10YR, 4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Kashipura (V_6)	10YR, 5/3 Brown	10YR, 5/3 Brown	10YR, 4/2 Dark grayish brown	10YR, 4/2 Dark grayish brown
Jainiwas (V_7)	7.5YR, 5/6 Strong brown	2.5Y, 6/6 Olive yellow	7.5YR, 4/4 Brown	2.5Y, 5/6 Light olive brown
Ramajpura (V_8)	2.5Y, 5/6 Light olive brown	10YR, 4/3 Brown	10YR, 3/3 Dark brown	10YR, 3/2 Very dark grayish brown
Babai (V_9)	2.5Y, 6/4 Light yellowish brown	2.5Y, 6/8 Olive yellow	2.5Y, 5/4 Light olive brown	2.5Y, 5/4 Light olive brown

Table 3: Soil Texture (Sand, Silt and Clay %) of different villages of Bundi district, Rajasthan.

Villages	0-15 cm	15-30 cm
Kashpuriya (V_1)	Sand-33.65%, Silt-24.32%, Clay-42.03% Class: Clay	Sand-30.22%, Silt-19.47%, Clay-50.31% Class: Clay
Gambhira (V_2)	Sand-33.05%, Silt-24.77%, Clay-42.18% Class: Clay	Sand-30.08%, Silt-19.44%, Clay-50.48% Class: Clay
Manpura (V_3)	Sand-33.23%, Silt-24.68%, Clay-42.09% Class: Clay	Sand-30.14%, Silt-19.28%, Clay-50.58% Class: Clay
Karwar (V_4)	Sand-33.83%, Silt-28.24%, Clay-37.93% Class: Clay	Sand-33.65%, Silt-20.13%, Clay-46.22% Class: Clay
Mani (V_5)	Sand-33.19%, Silt-28.26%, Clay-38.55% Class: Clay	Sand-33.04%, Silt-28.16%, Clay-38.8% Class: Clay
Kashipura (V_6)	Sand-33.37%, Silt-28.48%, Clay-38.15% Class: Clay	Sand-33.29%, Silt-28.34%, Clay-38.37% Class: Clay
Jainiwas (V_7)	Sand-46.08%, Silt-27.01%, Clay-26.91% Class: Clay loam	Sand-40.34%, Silt-25.56%, Clay-34.1% Class: Clay loam
Ramajpura (V_8)	Sand-46.13%, Silt-27.22%, Clay-26.65% Class: Clay loam	Sand-40.38%, Silt-24.69%, Clay-34.93% Class: Clay loam
Babai (V_9)	Sand-46.74%, Silt-27.78%, Clay-25.48% Class: Clay loam	Sand-40.55%, Silt-24.95%, Clay-34.5% Class: Clay loam

Table 4: Physical properties of soil of different villages of Bundi district, Rajasthan.

Villages	Bulk density (Mg m^{-3})			Particle density (Mg m^{-3})		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
Kashpuriya (V_1)	1.18	1.30	1.24	2.22	2.33	2.28
Gambhira (V_2)	1.11	1.21	1.16	2.5	2.59	2.55
Manpura (V_3)	1.25	1.39	1.32	2.86	2.98	2.92
Karwar (V_4)	1.24	1.32	1.28	2.52	2.61	2.57
Mani (V_5)	1.17	1.25	1.21	2.58	2.66	2.62
Kashipura (V_6)	1.33	1.43	1.38	2.62	2.65	2.64
Jainiwas (V_7)	1.42	1.57	1.50	2.60	2.64	2.62
Ramajpura (V_8)	1.28	1.47	1.38	2.85	2.94	2.9
Babai (V_9)	1.36	1.46	1.41	2.56	2.67	2.62
Mean	1.26	1.38		2.59	2.67	
	F-test	S. Ed(±)	C.D. at 0.05%	F-test	S. Ed (±)	C.D. at 0.05%
Due to depth	S	0.08	0.00001	S	0.06	0.00004
Due to site	S	0.12	0.00002	S	0.19	0.00000006

Table 5: Physical properties of soil of different villages of Bundi district, Rajasthan.

Villages	Pore space (%)			Specific Gravity		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
Kashpuriya (V_1)	46.85	44.21	45.53	1.92	2.02	1.97
Gambhira (V_2)	55.6	53.28	54.44	2.2	2.29	2.25
Manpura (V_3)	56.29	53.36	54.83	2.14	2.30	2.22
Karwar (V_4)	50.79	49.43	50.11	2.11	2.25	2.18
Mani (V_5)	54.65	53.01	53.83	2.12	2.25	2.19
Kashipura (V_6)	49.24	46.04	47.64	2.08	2.21	2.15
Jainiwas (V_7)	45.38	40.53	42.96	2.05	2.23	2.14
Ramajpura (V_8)	55.09	50	52.55	2.03	2.19	2.11
Babai (V_9)	46.87	45.32	46.1	1.95	2.11	2.03
Mean	51.2	48.35		2.07	2.21	
	F-test	S. Ed(±)	C.D. at 0.05%	F-test	S.Ed (±)	C.D. at 0.05%
Due to depth	S	2.01	0.000243	S	0.1	0.0000007
Due to site	S	4.39	0.00001	S	0.09	0.00002

Table 6: Water holding capacity (%) of soil of different villages of Bundi district, Rajasthan.

Villages	0-15 cm	15-30 cm	Mean
Kashpuriya (V_1)	58.82	54.29	56.56
Gambhira (V_2)	63.64	60.61	62.13
Manpura (V_3)	59.38	54.55	56.97
Karwar (V_4)	58.82	54.29	56.56
Mani (V_5)	57.58	52.94	55.26
Kashipura (V_6)	59.38	54.55	56.97

Jainiwas (V_7)	50	45.95	47.98
Ramajpura (V_8)	55.88	48.65	52.27
Babai (V_9)	54.29	47.37	50.83
Mean	57.53	52.58	
	F- test	S. Ed (±)	C.D. at 0.05%
Due to depth	S	3.50	0.000004
Due to site	S	4.15	0.00001

Conclusion
It is concluded that soil parameters were studied during the course of investigation responded good physical properties. By analysing the taken soil sample, soil was Clay and Clay loam, it has mixture of sand, silt and clay. Soybean, paddy, maize, sorghum, black gram and green gram are the main Kharif crops whereas wheat, mustard, barley and gram are the major Rabi crops of the district. We concluded that there is a need of adding soil amendments for maintaining soil physical properties. Soil amendment will improve soil texture and structure which improves all the other physical properties of the soil. Therefore, soil amendment will be helpful in maintaining to soil health and soil quality. The judicious use of organic manure in combination with inorganic fertilizers not only paves the way for achieving sustainable yields of crops but also maintains health of our finite soil without deterioration for future generations.

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