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Research Article

SOIL CHARACTERISTICS MAPPING FOR RUKHED WATERSHED

PATIL D.B.[1], TALEY S.M.[2], KALE M.U.[3]*, UPADHYE S.K.[4], SUPE M.S.[5] AND JADHAV K.A.[6]

[1,2,4,5]Department of Soil and Water Conservation Engineering, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra 444104
[3]Department of Irrigation and Drainage Engineering, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra 444104
[6]AECC, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra 444104
*Corresponding Author: Email-kale921@gmail.com

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Abstract- The knowledge of soil characteristics is essential for land use planning and water resource management in agriculture. Soil characteristics mapping was carried out using standard methods for Rukhed watershed in Akot taluka of Akola district of Maharashtra State. The soils of watershed are categorized into eight classes *viz.* clay loam, gravelly clay, gravelly clay loam, gravelly sandy clay loam, gravelly sandy loam, sandy clay loam, Silty loam and clay based on PSD analysis. The hydraulic properties of the soils of watershed were varied greatly over the area. Hydraulic conductivity was found varying from 0.84 to 1.24 $cmhr^{-1}$, bulk density from 1.31 to 2.56 gcm^{-3} and particle density from 2.44 to 2.66 gcm^{-3}. Similarly, the porosity was varying from 32.21 to 38.56%. While the EC, pH and organic carbon varied from 0.116 to 0.299 dsm^{-1}, 6.95 to 8.09 and 0.41 to 0.83 % respectively. The contour maps for physical properties of soil and water retention curves were developed for the Rukhed watershed and can be used as a ready reckoner for the future studies.

Keywords- Watershed, Water Retention, Bulk density, EC, pH

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Introduction

India is basically an agrarian country with geographical area of 328.73 Mha; of which reported area for land use is 306.04 Mha. Out of net cropped area, more than 60 percent of area is under rainfed agriculture. Interacting in a complex manner to influence human lives and activities, soil and water are among the major resources impacting upon the Earth's hydro geological and biological systems [1]. Soil characteristics are important in view of availability of soil-water to plants and to model movement of water and solutes in unsaturated soils.

The knowledge of soil hydraulic properties is essential for land use planning and water resource management in agriculture. Under climate change scenario, it is pertinent to study soil-water dynamics in detail for managing rainfed as well as irrigated agriculture. The study related to soil water dynamics needs an input of two important soil hydraulic properties *viz.* saturated hydraulic conductivity and soil water retention characteristics of which the data are however rarely available. Further the expenditure, time and manpower required to collect such critical information is very high. The researchers, planners and administrators therefore have to rely on limited available database [2]

Considering the importance of soil properties in water resource planning, this study was carried out at Rukhed watershed area Akot taluka of Akola district with objective of mapping the soil characteristics.

Materials and Methods

Study area

The study area *i.e.* Rukhed watershed, is situated between latitude of 21^0 12' 30" North and longitude of 77^0 12' 30" East. The total area of watershed is 6025.30 ha. The climate of the study area is sub-tropical and characterized by hot dry summer and cool winter. Rains are mostly received from South-West monsoon through June to October with mean annual precipitation of 842.6 mm. Winter rains are uncertain but has an average of 86.9 mm during October to January.

Spatial data

Spatial soil map [Fig-1] for watershed revealed that the watershed is comprised of eight types of soils *viz.* clay loam, clay, gravelly clay, gravelly clay loam, gravelly sandy clay loam, gravelly sandy loam, sandy clay loam, silty loam. Majority of soil is under clay loam, clay, gravelly sandy clay loam texture.

Collection of soil samples

To characteristic the properties of soil of watershed, the study area was divided into 15 grids of 2×2 km. Five samples were collected from each grid from the depth of 0-30 cm. Soil samples were then dried in air and grounded to pass through 2 mm sieve and mixed well to form a composite samples. The composite samples were used for grid wise physico-chemical analysis. Also samples from three major soil type of the watershed area were used for water retention study.

Physico-chemical analysis

Particle size distribution, particle density, bulk density, saturated hydraulic conductivity, water retention study, porosity, pH, Electrical Conductivity (EC), organic carbon were determined.

Particle size distribution was performed according to Bouyoucos (1962) Hydrometer method. Bulk density was determined by cold method [3,4]. Hydraulic conductivity was determined in the laboratory with a constant head permeameter as suggested by Richards (1954) [5]. Soil pH was determined in soil suspension (1:2.5, Soil: Water) by glass electrode pH meter after equilibrating soil with water for 30 minutes with occasional stirring.

The soil water suspension (1:2.5; Soil: Water) prepared for measuring pH was also used for measuring electrical conductivity using Electrical Conductivity Meter. Organic carbon was determined by Walkey and Black rapid titration procedure [6].
Particle density of soil refers to the density of the solid particles. It is expressed as the ratio of the total mass of the soil (solid) particles to their total volume, excluding pore space between particles. Pycnometers were used to determine particle density [7].

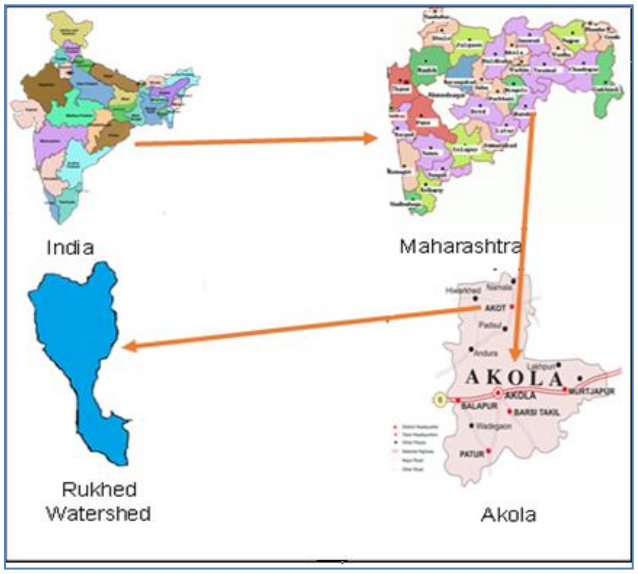


Fig-1 Location map for Rukhed watershed

Porosity is an index of the relative volume of pores. It is influenced by the structural and textural characteristics of the soil. Porosity can be defined as the ratio of the volume of pores (voids) to the total soil volume. The porosity of different soils was determined using following relationship.

$$\text{Porosity} = \left(1 - \frac{\text{Bulk density}}{\text{Particle density}}\right) \times 100$$

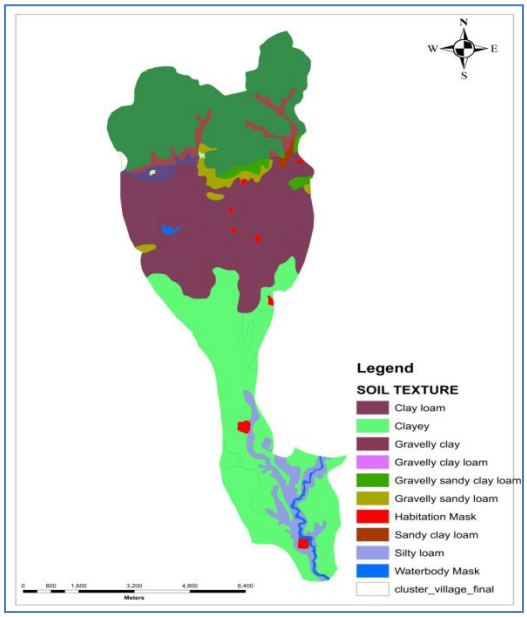


Fig-2 Soil map for Rukhed watershed

Water Retention Study

The soil water retention study was carried out using pressure plate apparatus as per method outlined by Richard (1954). Flow of moisture in unsaturated zone is governed by Richard's equation. For solving Richard's equation two important hydraulic functions, *viz.*, soil moisture retention curve $\Psi(\theta)$ and hydraulic conductivity function $K(\theta)$ are needed for the soils to be characterized. The soil moisture retention within available range of 0.33 to 15 bar *i.e.* 0.33, 5, 7, 10, and 15 bar were determined with pressure plate apparatus.
The empirical van Genutchen model [8] is fitted to the experimental data and relationship is extrapolated using cubic spline method, over the range for pF=0 to 6, *i.e.* up to 1000 atmospheres in view to determine VGM parameters for three major soil class *i.e.* clay, clay loam, and gravelly sandy clay loam.

Result and Discussion

Land Characteristic

Grid wise collected soil samples were analysed in the laboratory.

Particle size distribution

Grid wise particle size distribution and subsequent texture class for Rukhed watershed is presented in [Table-1]. The textural classes of soil samples were categorised as per USDA textural classification.

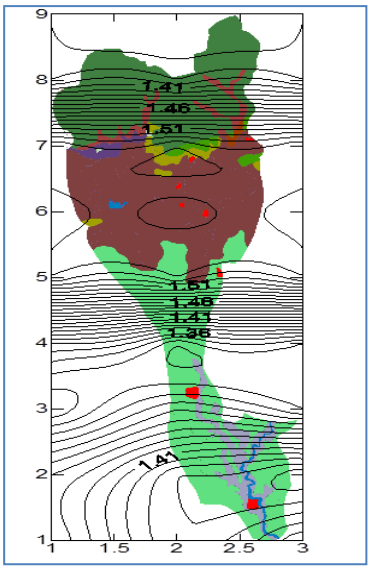
Table-1 *Textural classification of soils of watershed*

Grid No.	Particle size analysis			Textural Class
	Sand, %	Silt, %	Clay, %	
1	51.74	18.82	29.44	Gravely sandy clay loam
2	59.74	13.85	26.68	Sandy clay loam
3	49.12	17.78	33.01	Gravely sandy clay loam
4	60.89	13.78	25.33	Sandy clay loam
5	24.00	38.62	37.38	Clay loam
6	51.76	21.78	26.46	Gravely sandy loam
7	25.88	38.43	35.69	Clay loam
8	24.91	18.88	56.21	Gravelly clay loam
9	25.05	37.78	36.72	Clay loam
10	24.58	38.12	37.30	Clay loam
11	36.73	14.92	48.35	Gravelly clay
12	24.81	25.12	50.07	Clay
13	24.23	25.89	49.88	Clay
14	28.13	48.33	23.54	Silt loam
15	27.88	47.76	24.36	Silt loam

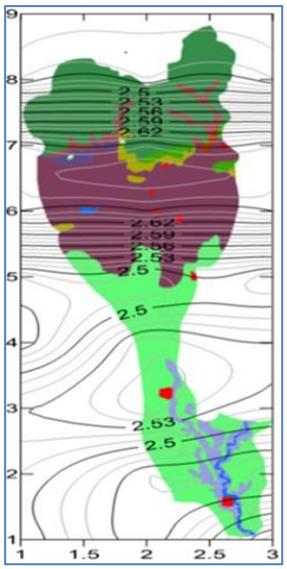
It is cleared from [Table-1] that the sand, silt and clay content in the soils of the watershed was found varying between 24.00 to 60.89%, 13.78 to 48.33% and 23.54 to 56.21%, respectively. Thus, the soils of watershed are categorised in eight soil textural classes as gravelly sandy clay loam, sandy clay loam, clay loam, gravelly sandy loam, gravelly clay, gravelly clay loam, clay and silt loam. The three major soil classes were found such as gravelly sandy clay loam, clay loam and clayey soil texture. The area under gravelly sandy clay loam, clay loam and clayey soil were found as 1027.18 ha, 868.12 ha and 535.27 ha respectively.

Physico-chemical properties of soil

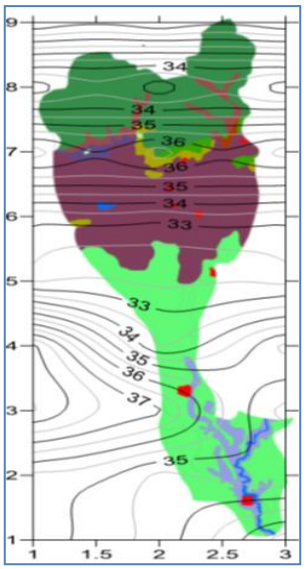
The grid wise physico-chemical properties of soil are presented in [Table-2]. The contour maps for physical properties of soil were also developed for the watershed area as a ready reckoner and depicted in [Fig-3].
Hydraulic conductivity was found varying from 0.84 to 1.24 $cmhr^{-1}$. Bulk density was found varying from 1.31 to 1.55 gcm^{-3}, while particle density was varying from 2.44 to 2.66 gcm^{-3}. Similarly the porosity was varying from 32.21 to 38.56%. EC and pH varies from 0.116 to 0.299 dsm^{-1}, and 6.95 to 8.09, respectively. While organic carbon was found varying from 0.37 to 0.83 % over the watershed area.
It is revealed from [Table-2] that there is large variation in the soil water retention characteristics of the soils of the watershed. The field capacity (FC) and permanent wilting point (PWP) of the clay soil was found in the range as 31.52 to 33.84% and 10.38 to 11.27%, respectively; while maximum available water capacity varied from 21.14 to 22.57%. FC and PWP for course textured soils (clay loam, sandy clay loam and silt loam) was found to be in the ranges of 29.71 to 38.00 % and 16.00 to 19.32 % respectively, while available water capacity was in the range of 12.56 to 20.47%. Similarly, FC and PWP of moderately textural soils (gravelly clay, gravelly clay loam, gravelly sandy loam and gravelly sandy clay loam) was found varying from 22.20% to 36.26% and 6.55 to 22.40% respectively, while available water capacity was in the range of 11.88 to 22.70%. These results are in conformity with those reported by Rawls *et al.* (1993).



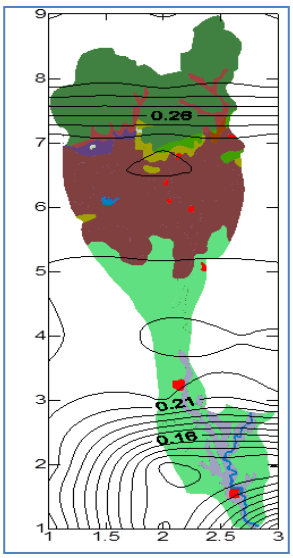
a) Bulk density



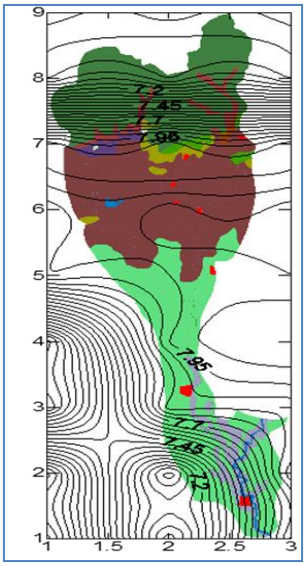
b) Particle density



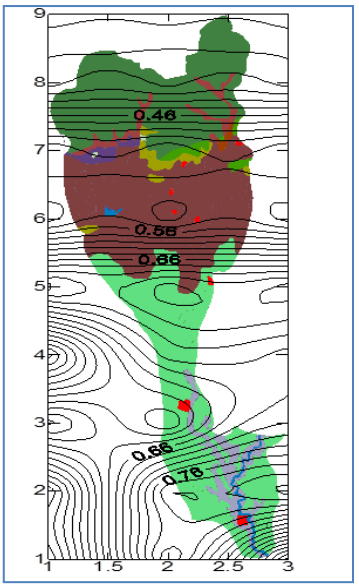
c) Porosity



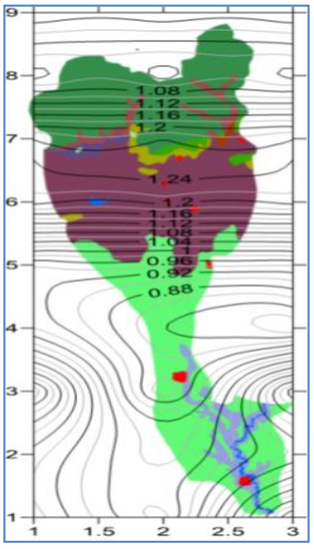
d) Electric Conductivity



e) pH



f) Organic Carbon



g) Hydraulic Conductivity

Fig-3 Contour maps of various soil properties

Table-2 *Grid wise physico chemical properties of soil*

Grid No.	Ks $cmhr^{-1}$	BD gcm^{-3}	PD gcm^{-3}	Porosity %	EC dsm^{-1}	PH	Organic carbon %	FC, %	PWP, %	AWC, %
1	1.03	1.38	2.51	35.37	0.218	7.93	0.46	33.61	14.85	18.76
2	0.93	1.44	2.46	34.34	0.116	6.96	0.80	31.25	14.73	16.52
3	1.23	1.40	2.55	32.21	0.222	7.86	0.51	29.64	17.76	11.88
4	1.02	1.46	2.44	35.01	0.117	7.94	0.83	38.00	19.03	18.97
5	1.16	1.31	2.53	38.56	0.224	6.95	0.69	36.25	11.74	24.51
6	0.84	1.36	2.56	37.11	0.221	7.88	0.58	34.52	11.82	22.70
7	1.14	1.33	2.52	34.28	0.219	7.86	0.70	31.20	10.50	20.70
8	0.94	1.36	2.46	38.16	0.232	6.97	0.47	36.26	22.40	13.86
9	0.84	1.32	2.55	33.40	0.216	7.96	0.69	31.40	10.93	20.47
10	0.80	1.33	2.53	35.69	0.219	8.05	0.67	34.27	15.53	18.74
11	0.94	1.54	2.48	32.39	0.229	7.95	0.75	22.20	6.55	15.65
12	1.21	1.53	2.65	33.17	0.235	7.92	0.51	31.52	10.38	21.14
13	1.24	1.55	2.66	36.78	0.231	8.09	0.56	33.84	11.27	22.57
14	1.03	1.39	2.46	32.64	0.299	6.99	0.37	29.71	16.00	13.71
15	1.14	1.38	2.47	37.51	0.289	7.08	0.41	31.88	19.32	12.56

Table-3 *Average hydraulic properties and VGM parameters for different soils of the watershed*

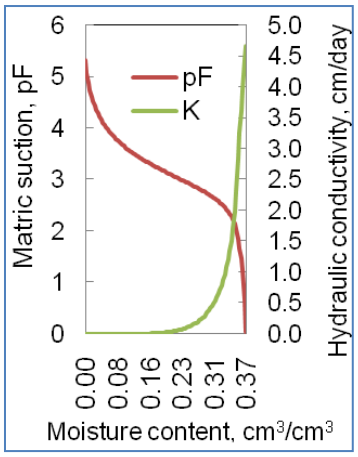
Grid No.	Texture	Water retention at		Saturated moisture content, cm^3cm^{-3}	Residual moisture content, cm^3cm^{-3}	VGM+ parameters	
		33 kPa cm^3cm^{-3}	1500 kPa cm^3cm^{-3}			α	n
12	Clay	0.32	0.17	0.44	0.07	0.032	1.19
5	Clay loam	0.36	0.18	0.45	0.07	0.033	1.20
1	Gravelly sandy clay loam	0.30	0.15	0.47	0.08	0.035	1.269

+van Genuchten model parameters [9]

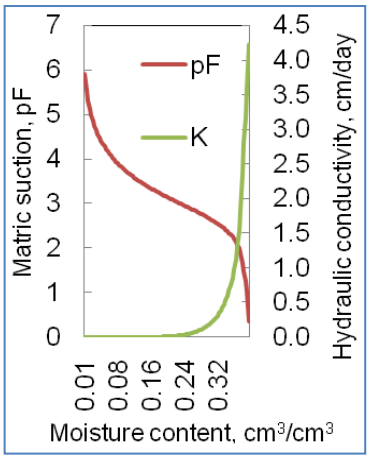
Soil moisture retention

The basic soil moisture retention properties and VGM parameters for three major soil class *i.e.* clay, clay loam, and gravelly sandy clay loam were determined using collected soil samples and are presented in [Table-3]. Water retention curves were also developed and depicted in [Fig-4] as a ready reckoner for future studies.

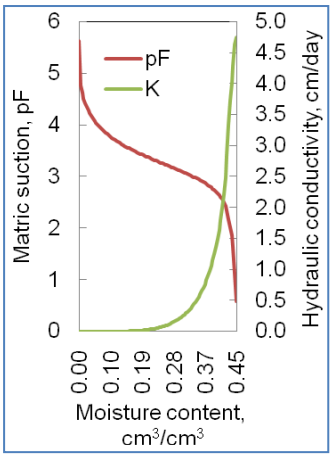
It is seen from [Fig-4(a)] that as the moisture content increase from 0 to 37%, the matric suction decreases 5.3 to 0.1, whereas hydraulic conductivity increases from 0 to 4.7cm day^{-1}. It is seen from [Fig-4(b)] that as the moisture content increase from 0 to 38%, the matric suction decreases 5.9 to 0.3, whereas hydraulic conductivity increases from 0 to 4.1 cm day^{-1}. It is seen from [Fig-4(c)] that as the moisture content increase from 1 to 38%, the matric suction decreases 5.7 to 0.5, whereas hydraulic conductivity increases from 0 to 4.7 cm day^{-1}.



(a) Clay soil



(b) Clay loam soil



I Gravelly sandy clay loam

Fig-4 Soil moisture characteristics curves

Conclusion

Soil characteristics mapping was carried out using standard methods for Rukhed watershed in Akot taluka of Akola district of Maharashtra State. The soils of watershed are categorized into eight classes *viz.* clay loam, gravelly clay, gravelly clay loam, gravelly sandy clay loam, gravelly sandy loam, sandy clay loam, Silty loam and clay based on PSD analysis. The hydraulic properties of the soils of watershed were varied greatly over the area. Hydraulic conductivity was found varying from 0.84 to 1.24 $cmhr^{-1}$. Bulk density was found varying from 1.31 to 2.56 gcm^{-3}, while particle density was varying from 2.44 to 2.66 gcm^{-3}. Similarly the porosity was varying from 32.21 to 38.56%. While the EC, pH and organic carbon varies from 0.116 to 0.299dsm^{-1}, 6.95 to 8.09, and 0.41 to 0.83 %, respectively. The contour maps for physical properties of soil were developed as a ready reckoner. Soil characteristics mapped as contours can be used as a ready reckoner for the future studies related to Rukhed watershed. Water retention curves developed can also be as a ready reckoner for the future studies. The knowledge of soil characteristics is essential for land use planning and water resource management in agriculture on watershed basis.

Conflict of Interest: None declared

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