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Original Research Article

Soil Moisture, available water and Physical Properties of soils of Some Selected Pedons at Undulated Hilly Terrain of Dangs District, South Gujarat

Ruplal Prasad[1*], A. Das[1], J. P. Kumar[2] and Asisan Minz[2]

[1]Department of Soil Science and Agricultural Chemistry, N.M. College of Agriculture, Navsari Agricultural University, Navsari- 396 450, India
[2]Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi-834006, India
**Corresponding author*

A B S T R A C T

An investigation was carried on "Soil Moisture, available water and Physical Properties of soils of Some Selected Pedons at Undulated Hilly Terrain of three villages named "Motidabdar, Chikhalda and Daguniya" in Waghai taluka of Dangs district in South Gujarat. The bulk density of pedons of Motidabdar, Chikhalda and Daguniya village found to mean value of 1.53, 1.60 and1.57 Mg m-3 respectively. The mean percent of soil porosity (> 2mm) in Motidabdar village of pedon 1, 2 and 3 was 37.54%, 27.86% and 26.18% respectively, while mean value of the Chikhalda village was lower and the Daguniya village higher as compared to Motidabdar village. In case of P_2 and P_3 mean percent of soil porosity of Chikhalda and Daguniya village were higher than Motidabdar village. Coarse fragments of three villages contained >35% of gravels/coarse fragments (>2 mm), except upper few horizons of some pedons. Maximum water holding capacity (MWHC) of soils of three pedons from Motidabdar village was found to vary from 32.87 to 45.74 % with general decreasing trend down the depth of pedons. Likewise, the corresponding value for pedons of Chikhalda and Daguniya village also showed the same trend. Available water capacity (AWC) (< 2 mm fraction) of pedon 1, 2 and 3 of Motidabdar village varied from 10.95-14.53, 14.78- 15.06 and 11.61 - 15.50 % respectively and the corresponding values for Chikhalda is lower and Daguniya village was higher than Motidabdar village.

Keywords

Soil Moisture, Physical Properties, Pedons, Undulated Hilly Terrain

Introduction

Worldwide, soil moisture is the main limiting factor in most agricultural systems (Farooq *et al.*, 2009) especially under undulating hilly terrain under Dang district. More than 50 percent of the global land surface under dry land or rain-fed condition (Asner and Heidebrecht, 2005) and South Gujarat is also a part of this situation. In all climates suitable for agriculture, the water storage capacity of soils is a crucial property for soil functionality including the productivity function (Jones *et al.*, 2009).

In the pedological approach, the different parameter of soil physical properties viz., porosity, soil moisture constants, gravel percentage and bulk density play a vital role towards soil classification but it has received major emphasis for several decades. But still lately, functional characterization of soil

units in space and time as well as physical properties of soils is slowly receiving more attention (e.g. Stolte *et al.,* 2003; Hessel *et al.,* 2003) and this is particularly interesting for practical applications for farmers and researchers. Keeping the above facts in mind, present study has done on soil moisture dynamics on help to improve the physical properties of some selected pedons at undulated hilly terrain of Dangs district in South Gujarat.

Materials and Methods

The present investigation was carried out in three villages named Motidabdar, Chikhalda and Daguniya in Waghaitaluka of Dangs district in South Gujarat. Motidabdar, Chikhalda and Daguniya villages situated at latitude and longitude of 20º42'33"N and 73º35'58" E, 20º41'7" N and 73º35 '50" E and 20º38'31"N and 73º36'6" E, respectively with their altitude varied from 275 to 355, 210 to 360 and 315to 355 m above from the sea level.

The average rainfall of last ten years (Fig. 1) was 2227 mm with an average of 68 annual rainy days (Fig 1). The wettest month is July with precipitation of around 500 to 700 mm. The maximum and minimum annual temperature of last ten years was 29.16^{o}C and 20.47^{o}C, respectively. The mean maximum temperature is the highest in the May.

The entire sub watershed falls under hyperthermic temperature regime with the mean annual soil temperature above 29^{o}C with an ustic moisture regime. The relative humidity was the minimum during January and February and it reaches to minimum during the monsoon months and maximum during summer months. Soils are hilly undulating highly dissected piedmont plateau and escarpment slope are shallow with excessive relief. The soils are stony/ gravelly in surface and moderate to severely eroded, non-calcareous and generally neutral to slightly acidic reaction, imperfect to well drained and highly permeable. The crops grown in the study area during *Kharif are p*addy and miner millets followed by blackgram, groundnut, pegeonpea, Niger, while groundnut, gram and vegetables are grown during *Rabi* season. Depending upon varying physiographic position, slope.

Nine representative pedons were dug out and were examined by following standard procedures. From the each of such pedons different layers were identified carefully, varying characteristics of pedons along with site characteristics were noted down. Collected of soil samples were done from different horizons and depths of all pedons as per standard procedure. The collected soil samples were air- dried, ground in wooden plank and rollers, passed through a 2 mm stainless steel sieve and analyzed for various physical properties The bulk density of soil was determined by core method as described by Black page *et al.,* (1965), Porosity was determined by using computation formula by Richards (1965) and Maximum water holding capacity (< 2mm fraction) was measured by using Keen Raczkowski by Piper (1950).

During examination of pedons, the coarse fragments present in each horizon of soils were expressed as percentage weight by subtracting the weight of soil <2 mm size from 100 gm of original soil collected at field during sample collection and soil moisture at 33 kpa and 1500 kPa were determined by pressure plate membrane apparatus (Richards, 1965). Available water capacity was estimated by subtracting water content at 33 kPa and 1500 kpa and was expressed as weight by weight (W/W) and volume by volume (V/V) %.

Results and Discussion

Bulk density (BD)

The bulk density of pedons of Motidabdar, Chikhalda and Daguniya of mean values 1.53, 1.60 and1.57 Mg m^{-3} respectively (Table 4, 5 & 6). Soils at higher elevation or at upper pediment, showed higher values of BD as compared to those at lower most elevation or at slightly flat land. This could be attributed to clogging of pores by dispersed clays in sub-soil layers and leaching loss of clay particle due to illuviation of upper surface in Dang district. Results were in good agreement with findings of Dhale and Prasad (2009). The variation in BD of soils in different pedons of three villages might be attributed to the variation in clay along with coarse fractions/ gravels, partially decomposed rocks and intensity of plant roots/ organic matter in different horizons.

The results were conformity with the reported earlier by Leelavathi *et al.,* (2009) revealed that the bulk density of different pedons of the Yerpedumandal soils of Chittoor district varied from 1.15 to 1.61 Mg $m^{-3}$with an increasing trend with depth which might be due to more compaction, lower organic matter and less aggregation.

Porosity

The soil porosity (> 2mm) in pedon 1, 2 and 3 of Motidabdar village mean value of porosity 37.54, 27.86 and 26.18% chronologically (Table 4, 5 & 6). The corresponding values of porosity for Chikhalda and Daguniya village mean value of porosity were 35.82, 33.64 and 33.82% in Motidabdar and 42.05, 32.95 and 29.99% in Daguniya village respectively and When mean porosity of three pedons from each village were compared, it was observed that Daguniya village recorded the highest percentage of mean porosity (42.05) followed by Chikhalda (38%) and Motidabdar (27.54%).

Patel (2010) reported that the pore space ranged from 34.43 to 47.76 % (weighted mean of 42.55 %) in the soils of different land slopes of Meghal irrigation command area in Southern Saurashtra of Junagadh district (Gujarat).

Coarse fragments

All the pedons of Motidabdar, chikhalda and Daguniya village contained >35% of gravels/coarse fragments (>2 mm), except upper few horizons of some pedons. However, mean gravel for pedon 1, 2 and 3 of Motidabdar village were 45.94, 50.98 and 42.97 respectively and the corresponding values for Chikhalda and Daguniya village were 37.07, 50.01 and 56.93, and 41.74, 53.77 and 51.36 %, respectively (Table 4,5 & 6). Patil and Prasad (2004) found that the coarse fragments of some Sal supporting soils of Dindori district in Madhya Pradesh were ranged from 13.6 to 60.0%, which were increased with increase in depth of soil.

Maximum water holding capacity (MWHC)

MWHC of soils of three pedons from Motidabdar village vary from 32.87 to 45.74 % with general decreasing trend down the depth of pedons (Table 4). However, pedons mean MWHC value varied from 39.56 to 42.97 %. Likewise, the corresponding value for pedons of Chikhalda village varied from 36.26 to 45.10 % with pedon mean value ranging from 37.32 to 40.22 % (Table 5). In Daguniya village the same varied from 32.48 to 44.32 % with pedon mean value ranging from 37.14 and 39.30 %.

Table.1 Soil Moisture constants and Available water capacity of pedon- soils from Motidabdar village

Water content (W/W)				Water content (V/V)			AWSC (cm)
Depth (cm)	**33kPa**	**1500 kPa**	**AWC (W/W)%**	**33kPa**	**1500 kPa**	**AWC (V/V) %**	
Pedon 1							
0-15	23.11	9.12	13.99	33.97	13.41	20.57	3.08
15-34	24.62	10.09	14.53	35.95	14.73	21.21	4.02
34-64	19.26	8.31	10.95	29.28	12.63	16.64	4.99
64-90	17.23	6.06	11.17	27.40	9.64	17.76	4.61
Mean	**21.06**	**8.40**	**12.66**	**31.65**	**12.60**	**19.05**	**16.70 (Total)**
Pedon 2							
0-22	22.70	8.81	13.89	34.28	13.30	20.97	4.61
22-42	24.19	9.13	15.06	37.01	13.97	23.04	4.60
42-58	21.74	9.28	12.46	32.83	14.01	18.81	3.00
58-170	18.30	7.52	10.78	27.45	11.28	16.17	18.11
170-200	17.44	6.12	11.32	25.46	8.94	16.53	4.95
Mean	**20.87**	**8.17**	**12.70**	**31.41**	**12.30**	**19.11**	**35.27(Total)**
Pedon 3							
0-40	23.61	9.24	14.37	35.65	13.95	21.70	8.68
40-70	24.00	8.50	15.50	37.44	13.26	24.18	7.25
70-83	22.89	8.46	14.43	36.17	13.37	22.80	2.96
83-98	17.75	6.14	11.61	30.53	10.56	19.97	17.97
Mean	**22.06**	**8.09**	**13.98**	**34.95**	**12.79**	**22.16**	**36.86(Total)**

AWSC- Available water storage capacity

Table.2 Soil Moisture and Available water of Chikhalda village

Water content (W/W %)				**Water content (V/V %)**			**AWSC (cm)**
Depth (cm)	33kPa	1500 kPa	AWC (W/W)%	33kPa	1500 kPa	AWC (V/V) %	
Pedon 1							
0-5	19.26	7.23	12.03	28.70	10.77	17.92	0.89
5-35	18.24	8.26	9.98	28.45	12.89	15.57	4.67
35-60	18.00	8.08	9.92	28.62	12.85	15.77	3.89
60-86	17.85	7.50	10.35	29.10	12.23	16.87	4.38
86-120	16.61	7.27	9.34	27.41	12.00	15.41	5.23
Mean	**17.99**	**7.67**	**10.32**	**28.45**	**12.15**	**16.31**	**19.06 (Total)**
Pedon 2							
0-5	19.09	7.36	11.73	29.59	11.41	18.18	0.90
5-52	17.40	5.97	11.43	27.84	9.55	18.29	8.59
52-109	22.00	8.54	13.46	36.30	14.09	22.21	12.65
109-120	19.38	7.89	11.49	32.75	13.33	19.42	2.13
Mean	**19.47**	**7.44**	**12.03**	**31.62**	**12.10**	**19.52**	**24.27 (Total)**
Pedon 3							
0-5	19.15	7.15	12.00	29.30	10.94	18.36	0.91
5-42	19.71	8.11	11.60	30.94	12.73	18.21	6.73
42-62	20.71	7.08	13.63	32.93	11.26	21.67	4.33
62-80	23.15	10.34	12.81	38.43	17.16	21.26	3.82
80-95	24.00	9.16	14.84	39.36	15.02	24.34	3.65
95-110	23.20	9.00	14.20	38.98	15.12	23.86	3.57
Mean	**21.65**	**8.47**	**13.18**	**34.99**	**13.71**	**21.28**	**23.01 (Total)**

AWSC- Available water storage capacity

Table.3 Soil Moisture and Available water Daguniya village

Water content (W/W)				Water content (V/V)			AWSC(cm)
Depth (cm)	33kPa	1500 kPa	AWC (W/W)%	33kPa	1500 kPa	AWC (V/V) %	
Pedon 1							
0-10	24.44	8.87	15.57	36.17	13.13	23.04	2.30
10-42	24.53	11.76	12.77	37.29	17.88	19.41	6.21
42-67	18.71	6.16	12.55	27.69	9.12	18.57	4.64
67-78	17.89	6.80	11.09	26.30	10.00	16.30	1.79
Mean	**21.39**	**8.40**	**13.00**	**31.86**	**12.53**	**19.33**	**14.94(Total)**
Pedon 2							
0-10	26.64	10.05	16.59	42.36	15.98	26.38	2.63
10-42	18.29	7.27	11.02	28.35	11.27	17.08	5.12
42-62	16.79	7.85	8.94	27.70	12.95	14.75	2.95
62-80	16.24	7.16	9.08	26.63	11.74	14.89	2.68
80-100	14.77	5.59	9.18	23.78	9.00	14.78	2.95
Mean	**18.55**	**7.58**	**10.96**	**29.76**	**12.19**	**17.58**	**16.33 (Total)**
Pedon 3							
0-10	22.33	8.87	13.46	35.95	14.28	21.67	2.16
10-30	24.42	8.34	16.08	39.32	13.43	25.89	5.17
30-60	24.22	7.71	16.51	40.93	13.03	27.90	8.36
60-90	18.05	5.66	12.39	27.62	8.66	18.96	5.68
90-115	17.24	6.19	11.05	28.45	10.21	18.23	4.55
Mean	**21.25**	**7.35**	**13.90**	**34.45**	**11.92**	**22.53**	**25.92 (Total)**

AWSC- Available water storage capacity

Table.4 Some physical properties in Motidabdar villages of Dangs District

Profile Location	Horizon	Depth (cm)	Texture (<2.00 mm fraction)	Bulk Density Mg m^{-3}	Porosity (%)	MWHC (%) (<2.00 mm fraction)	**Coarse fragments / Gravel (%)**	
							>2mm(%)	<2.00mm(%)
Pedon-1								
N20°42'65.5" E73°35'87.5" A279m MSL	A3	0-15	C	1.47	31.94	44.71	26.73	73.27
	B1c	15-34	C	1.46	38.13	44.34	36.28	63.72
	B2c	34-64	Cl	1.52	38.96	39.90	58.38	41.62
	C	64-90	Sic	1.59	41.13	36.38	62.37	37.63
Mean				**1.51**	**37.54**	**41.33**	**45.94**	**54.06**
Pedon-2								
N20°42'63.6" E73°36'29.2" A309m MSL	A3	0-22	C	1.51	21.76	45.74	32.83	67.17
	B1	22-42	C	1.53	24.26	41.30	34.28	65.72
	B2	42-58	C	1.51	29.44	41.00	61.82	38.18
	C1	58-170	Cl	1.50	29.91	36.90	57.45	42.55
	C2	170-200	Cl	1.46	33.94	32.87	68.53	31.47
Mean				**1.50**	**27.86**	**39.56**	**50.98**	**49.02**
Pedon-3								
N20°43'21.5" E73°85'70.6" A352m MSL	A3	0-40	C	1.51	27.40	45.26	41.68	58.32
	B1c	40-70	C	1.56	29.41	44.19	60.00	40.00
	B2c	70-83	Cl	1.58	33.89	43.30	64.00	36.00
	C	83-98	Sc	1.72	14.00	39.12	69.28	30.72
Mean				**1.59**	**26.18**	**42.97**	**58.74**	**41.26**
Overall								
Range				**1.46-1.72**	**14.00-41.13**	**32.87-45.74**	**26.73-69.28**	**31.47-73.27**
Mean				**1.53**	**41.28**	**42.28**	**51.88**	**48.11**

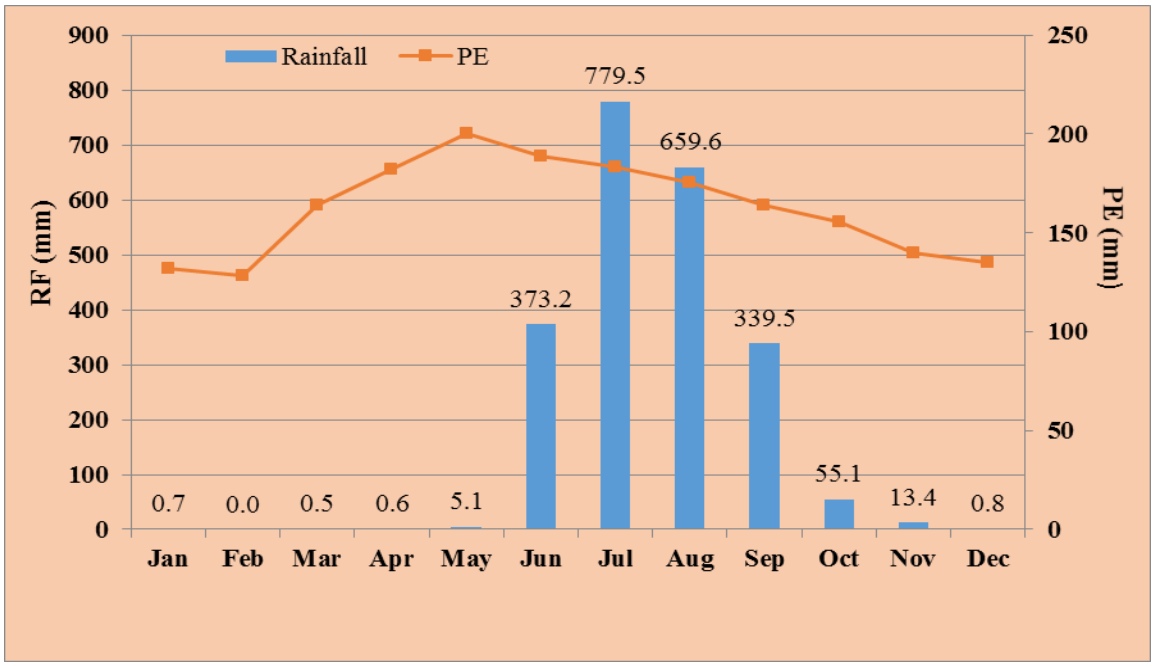
Table.5 Some physical in Chikhalda villages of Dangs District

Profile Location	Horizon	Depth (cm)	Texture (<2.00 mm fraction)	**Bulk Density Mg m^{-3}**	**Porosity (%)**	**MWHC (%) (<2.00 mm fraction)**	**Coarse fragments / Gravel (%)**	
							>2mm(%)	<2.00mm(%
Pedon-1								
N20°41'51.8 E73°35'65.2 A208m MSL	A1	0-5	L	1.49	33.47	36.50	30.20	69.80
	B21	5-35	L	1.56	34.65	38.35	33.25	66.75
	B22	35-60	L	1.59	34.73	36.80	34.00	66.00
	B31	60-86	L	1.63	38.02	37.25	38.52	61.48
	c1	86-120	Sl	1.65	38.20	37.70	49.38	50.62
Mean				**1.58**	**35.82**	**37.32**	**37.07**	**62.93**
Pedon-2								
N20°41'51.8 E73°35'65.2" A220m MSL	A2	0-5	L	1.55	27.57	37.85	33.80	66.20
	B1c	5-52	Sc	1.60	35.74	39.16	44.60	55.40
	B2c	52-109	Cl	1.65	35.04	40.16	60.76	39.24
	C1	109-120	C	1.69	36.23	36.26	60.86	39.14
				1.62	**33.64**	**38.36**	**50.01**	**50.00**
Mean								
Pedon-3								
N20°41'50.7. E73°35'60.9" A226m MSL	A1	0-5	L	1.53	27.83	38.30	42.38	57.62
	B1c	5-42	L	1.57	33.07	39.35	54.32	45.68
	B2c	42-62	L	1.59	34.31	37.90	58.29	41.71
	C1	62-80	L	1.66	36.14	36.65	52.23	47.77
	C2	80-95	C	1.64	34.65	44.05	68.35	31.65
	C3	95-110	C	1.68	36.92	45.10	66.05	33.95
Mean				**1.61**	**33.82**	**40.22**	**56.94**	**43.06**
Overall								
Range				**1.49-1.69**	**33.57-38.20**	**36.26-45.10**	**30.20-68.35**	**31.65-69.80**
Mean				**1.60**	**34.42**	**38.63**	**48.00**	**51.99**

Table.6 Some physical properties in Daguniya villages of Dangs District

Profile Location	Horizon	Depth (cm)	Texture (<2.00 mm fraction)	**Bulk Density Mg m^{-3}**	**Porosity (%)**	**MWHC (%) (<2.00 mm fraction)**	**Coarse fragments / Gravel (%)**	
							>2mm(%)	<2.00mm(%
Pedon-1								
N20°38'58.1" E73°35'95.0" A320m MSL	A1	0-10	C	1.48	50.00	44.00	34.90	65.10
	B1	10-42	C	1.52	30.59	43.36	40.17	59.83
	B2	42-67	Cl	1.48	50.17	39.05	48.02	51.98
	B3	67-78	Cl	1.47	37.45	39.32	43.86	56.14
Mean				**1.49**	**42.05**	**41.93**	**41.74**	**58.26**
Pedon-2								
N20°38'63.8" E73°36'22.0" A366m MSL	A2	0-10	C	1.59	36.65	44.32	39.01	60.99
	B1	10-42	Cl	1.55	20.92	37.71	52.02	47.98
	B2	42-62	Cl	1.65	37.02	36.09	62.00	38.00
	C1	62-80	Sc	1.64	28.70	35.09	66.19	33.81
	C2	80-100	Sc	1.61	41.45	32.48	49.62	50.38
Mean				**1.61**	**32.95**	**37.14**	**53.77**	**46.23**
Pedon-3								
N20°38'59.7 E73°36'24.5 A376m MSL	A2	0-10	Sic	1.61	19.50	36.62	36.50	63.50
	B1	10-30	Cl	1.61	33.74	38.50	42.16	57.84
	B2	30-60	Cl	1.69	31.85	38.09	54.51	45.49
	c1	60-90	Sc	1.53	44.57	41.00	53.82	46.18
	C2	90-115	Sc	1.65	20.29	42.32	69.83	30.17
Mean				**1.62**	**29.99**	**39.30**	**51.36**	**48.64**
Overall								
Range				**1.47-1.69**	**19.50-50.17**	**32.48-44.32**	**34.90-69.83**	**30.17-65.10**
Mean				**1.57**	**34.99**	**39.45**	**48.95**	**51.10**

Fig.1 Hydrograph of sub watershed area of Dangs district (1994-2014)



MWHC was found to decrease generally with depth of soil in pedon 1 and 2 which might be due to the variation in finer and coarse fraction with depth of soil (Table 6). However, in third pedon MWHC was found to increase slightly with depth possibly due to increase in finer fraction with depth. The results are strongly supported by the findings of Sharma *et al.,* (2001) mentioned that the water holding capacity in soils of Haldi Ghati region of Rajasthan were low to medium (17.10% to 37.30%) and Thangasamy *et al.,* (2005) The water holding capacity in soils of Sivagiri micro-watershed in Chittoor district of Andhra Pradesh ranged from 13.05 to 58.99 per cent. These differences were due to the variation in the depth, clay, silt and organic carbon content in the soils

Soil moisture constants and available water capacity (AWC)

AWC (< 2 mm fraction) of pedon 1,2 and 3 of Motidabdar village varied from 10.95-14.53, 14.78- 15.06 and 11.61 - 15.50 % respectively (Table 1) and the corresponding values for Chikhalda and Daguniya village were 9.34-12.03, 11.43- 13.46 and 11.60-14.86 %, and 11.09-15.56, 9.08- 16.51 and 11.05-16.51% % respectively (Table 2 & 3). However, mean pedon AWC were 12.66, 12.70 and 13.98 % for pedon 1, 2 and 3 of Motidabdar village and the corresponding values for Chikhalda and Daguniya village were 10.32, 12.07 and 13.18 %, and 13.00, 10.96, 13.90 %, respectively. The variation in AWC in different horizons as well as pedons might be ascribed to variation in organic matter, clay type and content. Results were in good agreement with findings of Singh *et al.,* (2008) reported that the water retention at 1500 and 33 kPa ranged from 3.4 - 5.8% and 11.2- 27.4% in shallow, 4.3 - 5.6, 15.1- 15.9% in moderate and 4.9-11.2, 12.7-23.6% in deep soils of Nagpur district, respectively and Balpande *et al.,* (2007) found that the water retention in different horizons of the soils of Nasik district varied from 19.56 to 50.22 at 33 kPa and 9.81 to 30.94 at 1500 kPa. However, when depth of all the pedons irrespective of

elevation and slopes were considered up to 60 cm, it was observed that pedon 3 in Motidabdar, Chikhalda and Daguniya villages recorded the highest available moisture storage capacity (cm) followed by pedon 1 and pedon 2 in Motidabdar and Daguniya village and Pedon 2 and 1in Chikhalda village.

The surface soils were gravely and sub-soils of all pedons were very gravely in nature and as a result not suitable as such for field crops, though soils exhibited good AWC in these villages.

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