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Assessment of Physico-Chemical Properties of Soil from Different Villages of Kushinagar District, Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was carried out during 2022 and consisted of soil sample collection from the designated sitesand laboratory experiments which was conducted in Department of Soil Science & Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007(U.P.). The primary goals of this study were to investigate the physico-chemical characteristics of soil at various depths. To determine the

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availability of macronutrients in soil samples from Kushinagar, District, UttarPradesh, and to provide an assessment, 9 sampling locations were chosen. The depths at which soil samples were taken were 0–15, 15–30 and 30–45 cm, respectively. The soil colour (dry condition) Results revealed that the soil colour in dry condition varies from Olive yellow to Olive grey and the colour in wet condition varies from Olive brown to Dark greyish. The soil texture was dominantly sandy loam in almost every site.The bulk density (Mg $m^{-}3$) ranged from 1.35(Mg m^{-3}) to 1.43(Mg m^{-3}). The practical density (Mg $m^{-}3$) ranged from 2.41 (Mg m^{-3}) to 2.53(Mgm^{-3}). The pore space (%) ranged from 43.87(%)to 48.87(%). The water holding capacity (%) ranged from 34.01(%) to 42.36(%). The soil pH ranged from 7.50 to 7.99 Indicating Neutral to alkalinein nature. The electrical conductivity ranged from 0.12 (dS $m^{-1)}$ to 0.33(dS m^{-1}). The soil organic carbon (%) ranged from 0.23(%) to 0.39(%). The Available nitrogen (kg ha^{-1}) ranged from 233.23(kg ha^{-1}) to 278.24 (kg ha^{-1}). The Available phosphorous (kg ha-1) ranged from 13.89 (kg ha-1) to 25.39 (kg ha-1). The Available potassium (kg ha-1) ranged from 187.99(kg ha-1 to 238.32 (kg ha- 1). The Exchangeable calcium [cmol (p+) kg^{-1}] ranged from 3.03 to 4.24 [cmol (p+) $kg-^{1}$]. The Exchangeable Magnesium [cmol (p+) kg^{-1}] ranged from 1.45 to 2.21 [cmol (p+) kg^{-1}]. It suggests that still improvement can be done by improving cropping pattern, decomposition of organic waste, mulching, tillage practices and proper irrigation by management practices with knowledge and experience gained through studies and lead farmers to achieve quality produce and high yield through soil conservation.

Keywords: Physico-chemical; bulk density; soil depth; macronutrients; electrical conductivity.

1. INTRODUCTION

"Soil is the natural medium for the growth of plants. Soil has also been defined as a natural body consisting of layers (soil horizons) that are composed of weathered mineral materials, organic materials, air and water. Soil is the end product of the combined influence of climate, topography, organisms (flora, fauna and human) on parent materials (original rocks and minerals) over time. As a result, soil differs from its parent material in texture, structure, consistency, colour, chemical, biological and physical characteristics" [1]. Soil is an essential component of "Land" and "Eco-systems" that both are broader concepts encompassing vegetation, water and climate in the case of land, and in addition to those three aspects, also social and economic considerations in the case of ecosystems [1]. "Soil may also be a non-renewable dynamic resource, comprising of unconsolidated minerals and organic matter including water and air within the uppermost layers of the earth's surface and plays a crucial role in maintaining the terrestrial ecosystem on which all life depends (Andrew *et al.,* 2020)**.** The chemical and physical properties of soil have a big role in a plant's ability to extract water and nutrients. Soil is that the product of biochemical weathering of the parent material and its formation is influenced by the soil formation factors like climate, organism, parent material, relief, and time" [2].

"The physical properties are Bulk Density(g/cc), Particle Density(g/cc), Pore space (%), Water Holding Capacity (%), Soil Colour, Soil Texture. The chemical properties are pH, Electrical Conductivity, % Organic Carbon, Available Nitrogen, Available Phosphorus, Potassium The knowledge about the physical and chemical properties helps in managing the resources while working with a particular soil. The aim is to set appropriate guidelines for sustainable productivity for better utilization and management of the soil for particular land use.All soils having different properties and working with them requires an understanding of these properties. They need to be studied for agricultural purposes, to increase productivity, and have to improve the workability of soil mass. The study of the up-to-date status of soilproperties is a very important tool to enhance production on a sustainable basis. The proper use of soil is the most vital and precious natural resource that sustains all kinds of the existence of life system and socio-economic development of any country in the world" [3].

2. MATERIALSANDMETHODS

2.1 Study Area

Uttar Pradesh is a state in south western region of India. The average rainfall here is about 990 mm and monsoon begin by June and till the end of October. The location of Kushinagar District GPS coordinates Latitude: 26° 44' 23.64" N and Longitude: 83° 53' 13.2" E. In area Kushinagar District covers 2873.15 sq. km, is bounded by

Maharajganj in west Gorakhpur in the southern west. Deoria in the south and the Bihar state in the East. The Kushinagar District is majorily Tarai area.

2.2 Soil Sampling

"The soil sample collection is from 1 blocks of Kushinagar District in the state of Uttar Pradesh. In one block selecting 9 villages. Samples was collected randomly from a site of each village using soil auger, Khurpi Knife by composite sampling method at a depth of 0- 15cm, 15-30 cm, 30-45 cm. A comparison of the Physico-chemical Properties of some of the soils of different regions of the Telangana state has been undertaken by comparing the results of the present study with the studies done earlier in the other state. Hence, a detailed study for evaluation of soils is needed to realize the concept of Physico- chemical analysis successfully. With this following objective, a study has been undertaken in soil resources inventory for sustainable land use planning in Kushinagar region of Uttar Pradesh" [4].

2.3 Analysis of Physico-chemical Parameters

"The soil sample collection is from 1 blocks of Kushinagar District in the state of Uttar Pradesh. In one block selecting 9 villages. Samples was collected randomly from a site of each village using with the help of soil auger, Khurpi Knife by composite sampling method at a depth of 0-15cm, 15-30 cm, 30-45 cm. A comparison of the Physico-chemical Properties of some of the soils of different regions of the Telangana state has been undertaken by comparing the results of the present study with the studies done earlier in the other state. Hence, a detailed study for evaluation of soils is needed to realize the concept of Physico- chemical analysis successfully. With this following objective, a study has been undertaken in soil resources inventory for sustainable land use planning in Kushinagar region of Uttar Pradesh" [4]. A hydrometer was used to determine the soil's textural class (Bouyoucos, 1927). The graduated measuring cylinder method was used to calculate bulk density, particle density, and water holding capacity (Muthuaval et al., 1992). After creating a 1:2.5 soil-water suspension, pH was calculated using a digital pH metre (Jackson, 1958). Digital conductivity metres were used to estimate electrical conductivity (Wilcox, 1950). Wet oxidation was used to measure the percentage of organic carbon (Walkley and Black, 1947).Available nitrogen was estimated by the alkaline potassium permanganate method using the Kjeldahl apparatus (Subbiah and Asija, 1956); available phosphorus was determined using Bray's extraction method (Bray and Kurtz, 1945); available potassium was determined using neutral normal ammonium acetate extraction followed by the flame photometric method (Toth and Prince, 1949); and exchangeable calcium and magnesium were determined using the EDTA method [5].

3. RESULTS AND DISSCUSION

Soil in different villages in Nebua Naurangia block. The texture Classification of soil samples was shown Sandy Loam in all villages. The percentage of sand (75.12%) in the village Padri Mehadia B1V1 to lowest sand (71.46%) in the village Raipur B1V8 Highest silt (18.36%) in the village Nebua B1V3 to lowest silt (14.45%) in the village Padri Mehadia B1V1 and highest clay (11.08 %) in the village Rahinapur B1V5 to lowest clay (9.18) in the village Sirsiya bujurga B1V7.

Bulk density of villages and depth which was found to be non-significant. The maximum value found is 1.43 Mg m-3 in B1V4 at 30-45 cm depth the minimum value found is 1.35(Mg m -3)B1V6 at 0-15cm depth. The bulk density increases with the increase in soil depth. The bulk density decreased due to the high organic matter content or vice versa. Similar results analyses were reported by [6]. The Particle Density (Mg m-3) ranged from 2.41 to 2.53(Mg m-3). The maximum value found is 2.53 ***(***Mg m-3) in B1V1 at 30-45cm depth the minimum value found is 2.41 (Mg m-3) B1V6 at 0-15cm depth. The range pore space (%) ranged from 43.87 to 48.87%. The maximum value found is 48.87**%** in B1V1 at 0-15cm depth and the minimum value found is 43.87% B1V5 at 30-45cm depth. "The pore space found to decrease with increase in depth at attributed to increase in compaction in the sub surface. Surface soils are having high amount of macro and micro pores compared to sub surface soil due to presence of high organic matter" [4].

Table 1. Soiltexture and soil colour of Kushinagar District

BlockName&Site	Soil Colour		SoilTexture
	Range(DryCondition)	Range(WetCondition)	
B_1V_1	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_2	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_3	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_4	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_5	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_6	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_7	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_8	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM
B_1V_9	OLIVE YELLOW	OLIVE BROWN	SANDY LOAM

Table 2. Evaluation of bulkdensity and particledensity of soils of Kushinagar District

Village	BulkDensity(Mg m-3)			Particle Density (Mg m-3)		
	0-15cm	15-30cm	30-45 cm	0-15cm	15-30cm	30-45 cm
B_1V_1	1.36	1.37	1.39	2.51	2.52	2.53
B_1V_2	1.38	1.39	1.41	2.45	2.46	2.48
B_1V_3	1.37	1.38	1.39	2.42	2.43	2.44
B_1V_4	1.41	1.42	1.43	2.48	2.49	2.50
B_1V_5	1.39	1.40	1.42	2.46	2.47	2.48
B_1V_6	1.35	1.36	1.37	2.41	2.42	2.44
B_1V_7	1.37	1.38	1.39	2.47	2.48	2.49
B_1V_8	1.38	1.39	1.40	2.44	2.45	2.46
B_1V_9	1.39	1.40	1.41	2.41	2.42	2.43
	F-Test	**S.Em. ±**	**C.D@5%**	**F-Test**	**S.Em. ±**	**C.D@5%**
Depth (0-15cm)	NS			**S**	0.031628	0.093971
Depth (15-30cm)	NS			**S**	0.038658	0.114857
Depth (30-45cm)	NS			**S**	0.037156	0.110397

Table 3. Estimation of water holding capacity, pore space (%) of Soils of Kushinagar District

Village	WaterHoldingCapacity(%)			PoreSpace(%)		
	0-15cm	15-30cm	30-45 cm	0-15cm	15-30cm	30-45 cm
B_1V_1	42.36	41.09	40.01	48.87	48.68	48.13
B_1V_2	40.25	39.06	38.04	45.23	45.05	44.40
B_1V_3	39.30	38.21	37.01	45.41	45.23	45.11
B_1V_4	41.09	40.05	39.01	46.79	46.61	46.44
B_1V_5	38.76	37.51	36.31	44.62	44.44	43.87
B_1V_6	36.39	35.20	34.01	42.68	42.51	42.33
B_1V_7	40.92	39.39	38.21	46.48	46.36	46.12
B_1V_8	39.76	37.52	36.74	45.45	45.27	45.09
B_1V_9	39.96	38.81	37.29	45.91	45.73	45.55
	F-Test	**S. Em. ±**	**C.D@5%**	**F-Test**	**S. Em. ±**	**C.D@5%**
Depth (0-15cm)	**S**	0.745704	2.215601	**S**	0.724075	2.151338
Depth (15-30cm)	**S**	0.501382	1.489681	**S**	0.449885	1.336678
Depth (30-45cm)	**S**	0.409082	1.215444	**S**	0.598181	1.777287

Table 4. Estimationof soil pH(1:2), EC (dsm^{-1}) and Organic Carbon (%)

.Village	pH			EC (dsm-1)			OC(%)		
	0-15cm	15-30cm	30-45 cm	0-15cm	15-30cm	30-45 cm	0-15cm	15-30cm	30-45 cm
B_1V_1	7.84	7.85	7.86	0.21	0.17	0.15	0.27	0.26	0.25
B_1V_2	7.66	7.68	7.73	0.27	0.24	0.22	0.29	0.38	0.36
B_1V_3	7.50	7.71	7.75	0.17	0.15	0.13	0.39	0.27	0.26
B_1V_4	7.67	7.68	7.72	0.29	0.26	0.24	0.31	0.30	0.29
B_1V_5	7.75	7.98	7.99	0.33	0.29	0.27	0.26	0.24	0.23
B_1V_6	7.91	7.93	7.96	0.22	0.18	0.16	0.34	0.32	0.31
B_1V_7	7.75	7.84	7.86	0.18	0.16	0.15	0.38	0.36	0.35
B_1V_8	7.58	7.63	7.65	0.17	0.15	0.13	0.29	0.26	0.25
B_1V_9	7.81	7.91	7.93	0.16	0.13	0.12	0.30	0.28	0.27
	F-Test	**S.Em. ±**	**C.D @5%**	**F-Test**	**S.Em.±**	**C.D 5%**	**F-Test**	**S.Em.±**	**C.D@5%**
Depth (0-15cm)	NS			S	0.003284	0.009758	S	0.003409	0.01013
Depth(15-30cm)	NS			S	0.002934	0.008719	S	0.003069	0.009119
Depth(30-45cm)	NS			S	0.003078	0.009145	S	0.002923	0.008685

Table 5. Evaluation of Available Nitrogen (Kgha^{-1}), Available Phosphorous (Kgha^{-1}) and Available Potassium (Kg ha^{-1})

Village	Nitrogen (Kgha-1)			Phosphorous(Kgha-1)			Potassium (Kg ha-1)		
	0-15cm	**15-30cm**	**30-45 cm**	**0-15cm**	**15-30cm**	**30-45 cm**	**0-15cm**	**15-30cm**	**30-45 cm**
B_1V_1	261.27	253.53	239.45	20.88	17.54	15.25	228.24	213.54	194.12
B_1V_2	264.24	268.45	251.32	24.83	20.96	18.23	235.25	220.24	201.23
B_1V_3	278.27	255.36	240.26	25.39	16.52	15.54	238.32	223.24	202.25
B_1V_4	260.26	248.45	234.65	22.27	15.35	14.23	218.44	205.25	186.24
B_1V_5	267.24	253.23	233.23	21.46	16.25	13.89	215.54	203.25	187.99
B_1V_6	270.45	258.45	242.56	24.25	18.26	16.45	231.42	216.42	197.12
B_1V_7	273.23	261.12	246.23	23.83	20.23	17.14	220.21	206.75	202.11
B_1V_8	265.25	254.23	238.56	22.86	16.35	14.23	221.25	207.25	189.11
B_1V_9	267.28	258.23	241.23	23.08	17.24	15.12	227.45	212.25	195.25
	F-Test	**S.Em. ±**	**C.D @5%**	**F-Test**	**S.Em.±**	**C.D 5%**	**F-Test**	**S.Em.±**	**C.D@5%**
Depth (0-15cm)	s	3.24876	3.65256	S	0.32995	0.98033	s	2.071231	6.153944
Depth(15-30cm)	s	3.11341	9.25042	S	0.202832	0.602644	s	2.035066	6.04649
Depth(30-45cm)	s	2.24885	6.68169	S	0.168481	0.500582	s	1.72046	5.11175

3.1 Chemical Properties

The values of pH of a soil sample ranged from 7.50-7.99 with 7.78 as a mean value. The maximum value found is 7.99 in B1V5 at 30-45cm depth and the minimum value found is 7.50 B1V3 at 0-15cm depth. The maximum value is due to the presence of organic matter and the reduction in pH value is due to the production of acids by bacterial nitrification processes in the soil and the decomposition of organic matter. Similar result analyseswas reported by [7].

Electric conductivity ranged from 0.12-0.33 dsm-1 with 0.196 as a mean value. The maximum value found is 0.33 dsm-1 B1V5 at 0-15cm depth and the minimum value found is 0.12 dSm-1 B1V9 at 0-15cm depth. According the results it is shown that 100% of the samples are in permissible range suitable for all type of crops. The low EC may be due to the good drainage condition which favored the removal of related bases by percolating.

The organic carbon ranged from 0.23-0.39 with 0.299 as a mean value. The maximum value found is 0.39 B1V3 at 0-15cm depth and the minimum value found is 0.23 B1V5 at 30-45cm depth. The soil organic Carbon content decreased with an increase in soil depth and this is due to the addition of plant residue and FYM to surface soil then in the sub-surface soil.

3.2 Primary Nutrients

The nitrogen content in soil sample ranges from 233.23 – 278.24 kg h^{-1} with 255.31 as a mean value. The maximum value found is 278.24 kg ha-1 in B1V3 village at 0-15 cm depth and the minimum value found is 233.23 kg ha-1 in B1V5 village at 30-45 cm depth. The available nitrogen was recorded maximum at 0-15 cm soil depth as compared to subsurface soil depth. The available new nitrogen decreased with the increase in soil depth [8]. **"**The Available Phosphorous in soil samples ranged from 13.89 – 25.39 kg h-1 with 18.80 as a mean value. The maximum value found is 25.39 kg ha-1 in B1V3 village at 0-15cm depth and the minimum value found is 13.89 kg ha-1 in B1V5 village at 30-45cm depth. Available Phosphorous decrease with the increasing depth. Higher level of Available Phosphorous in surface soil could be attribute of favorable soil pH and organic matter content" [9].

The Available Potassium content in the soil samples ranges from 187.99 – 238.32 kg h-1 with 211.20 as a mean value. "The maximum value found is 238.32 kg ha-1 in B1V3 village at 0-15cm depth and the minimum value found is 187.99 kg ha-1 in B1V5 village at 30-45cm depth. The high content of Available Potassium on surface soil may be attributed to the release of available K form organic residues and application of potassium fertilizers" [10].

Table 6. Estimation of Exchangeable Calciumand Magnesium [cmolKg^{-1}] in different blocks and sites

BlockName & Sites	ExchangeableCalcium[c mol kg-1]			ExchangeableMagnesium [c molKg-1]		
	0-15cm	**15-30cm**	**30-45 cm**	**0-15cm**	**15-30cm**	**30-45 cm**
B_1V_1	4.06	3.97	3.92	2.03	1.97	1.91
B_1V_2	3.75	3.64	3.56	1.97	1.91	1.85
B_1V_3	3.99	3.92	3.86	1.78	1.74	1.68
B_1V_4	4.02	3.94	3.89	2.01	1.96	1.91
B_1V_5	4.24	4.13	4.01	2.21	2.15	2.04
B_1V_6	3.99	3.92	3.87	1.98	1.91	1.86
B_1V_7	4.21	4.16	4.09	2.12	2.05	1.98
B_1V_8	4.19	4.14	4.09	2.14	2.06	1.99
B_1V_9	3.23	3.11	3.03	1.56	1.51	1.45
	F-Test	**S.Em. ±**	**C.D@5%**	**F-Test**	**S.Em. ±**	**C.D@5%**
Depth (0-15cm)	**S**	0.048483	0.14405	**S**	0.034363	0.102098
Depth (15-30cm)	**S**	0.050963	0.151418	**S**	0.032394	0.096248
Depth (30-45cm)	**S**	0.071759	0.213206	**S**	0.026653	0.079189

3.3 Secondary Nutrients

The Exchangeable Calcium [cmol (p+) kg -1] in soil samples ranges from 3.03– 4.24 [cmol (p+) kg -1]. The maximum value found is 4.24 kg ha-1 in B1V5 village at 0-15cm depth and the minimum value found is 3.03 [cmol (p+) kg -1] in B1V9 village at 30- 45cm depth. According to the range of Exchangeable Calcium decreases with the increasing in depth due to the attributes of high pH towards the depth [11]. "Magnesium of soil samples ranged from 1.45 – 2.21 [cmol (p+) kg $^{-1}$]. The maximum value found is 2.21 [cmol (p+) kg $^{-1}$] in B1V5 village at 0-15cm depth and the minimum value found is 1.45 [cmol (p+) kg $^{-1}$] in B1V9 village at 30-45cm depth. Exchangeable Magnesium decreases with the increasing in depth due to the attributes of high pH towards the depth" [12].

4. CONCLUSION

According to the soil test results of villages of Kushinagar district clearly states that the soil is in neutral to alkaline in condition. 100 % of the soil samples are in permissible limit of EC and suitable for most crops. Organic carbon is showing a low range this is because of high temperature and high rainfall and decomposition is rapid, 100 % of the soil samples are showing low in available nitrogen, 100% of soil samples are showing medium in Available phosphorus, Available potassium is in range of medium, Secondary nutrients is in range of low to high range. The major reason for lack of macronutrients is leaching due to higher amount of precipitation in the area, nutrient uptake by plants and inappropriate management practices. It suggests that still improvement can be done by improving cropping pattern, decomposition of organic waste, mulching, tillage practices and proper irrigation by management practices with knowledge and experience gained through studies and lead farmers to achieve quality produce and high yield through soil conservation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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