

Original Research Article

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## Assessment of Soil Health and Soil Quality of Kandhamal District, Odisha

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### ABSTRACT

#### Keywords

Soil health, Soil quality, pH, EC, Sulphur, Zinc, Kandhamal, Soil

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Maintenance of soil health is prime importance for sustainable crop production. Soil quality is rapidly de-creasing in many regions around the world. There are many reasons leading to soil quality deterioration, including changes in land use types from forest to arable land and the consequences from intensive land use. In the present investigation analysis of different physical and chemical characteristics were made to determine soil health of Kandhamal district. Results show that soil bulk density was in normal range, soil particle density varied from 2.22 to 3.33 g cm<sup>-3</sup>, soil pH and EC were found to be acidic and non-saline in nature respectively while soil organic carbon and available phosphorus were in medium to high range. Available nitrogen and potassium were found to be low to medium range i.e., 198.82 to 385.6 Kg ha<sup>-1</sup> and 82.23 to 167.6 Kg ha<sup>-1</sup> respectively. Deficiency of sulphur followed by zinc was found in soils of Kandhamal district.

### Introduction

Soils vary widely as a function of their position on the landscape and agricultural management, land use and cultivation intensity (Ayele *et al.*, 2020). Soil quality is simply defined as "the capacity of a specific kind of soil" (Karlen *et al.*, 1997), i.e., mainly to provide nutrition to plants and absorb and drain water. The different properties of soil are – texture, moisture, fertility (level of nitrogen, phosphorus, and potassium) and pH level, where the pH is the measure of a soil's acidity or alkalinity (Pham *et al.*, 2018). Unfortunately, soil quality is rapidly decreasing in many regions around the world

(Vitousek, Mooney, Lubchenco, & Melillo, 1997). There are many reasons leading to soil quality deterioration, including changes in land use types from forest to arable land (Oguike & Mbagwu, 2009) and the consequences from intensive land use (Jamala & Oke, 2013).

The present study was made to determine the health and quality of different soils collected from different villages of Kandhamal district. Different physical and chemical characteristics were analyzed to identify soil health related crop production constraints along with suggesting remedial measures for higher crop production. The colour of the soil

is one of the most important indications of the pedogenic processes (soil forming processes) as well as moisture status of the soil (Digal *et al.*, 2018). Soil organic matter accumulation improve SQ by decreasing bulk density (BD), surface sealing and crust formation (Mohanty *et al.*, 2007), and by increasing aggregate stability (Somasundaram *et al.*, 2013), cation exchange capacity, nutrient cycling, and biological activity (Karlen and Andrews, 2004). The most popular indicators used to assess soil quality are soil organic carbon (SOC), total nitrogen (TN) and soil acidity (pH) (Pham *et al.*, 2018). SOC is fundamental to soil fertility and is a strong indicator of a soil's biological health (Chan *et al.*, 2010) as well as its chemical, biological, and physical processes. TN is the main nutrient used for vegetation growth and is also used as a key soil quality assessment (Ren, Wang, Chen, Zhang, & Lu, 2014). Soil pH is one of the most important soil parameters and essential for agricultural production. Most agricultural crops develop best in soil with a pH from 5.5 to 6.5 (Havlin, Beaton, Tisdale, & Nelson, 1999).

## Materials and Methods

### Experimental site

Kandhamal district comes under North Eastern Ghat Agro Climatic Zone of Odisha (Nanda *et al.*, 2008). As per modern system of soil classification “Soil Taxonomy” the soils of Kandhamal district are classified under the *Alfisols*, *Inceptisols* and *Entisols* (Sahu & Mishra, 2005). It lies between 83° 30'E to 84° 48' E longitude and between 19° 34' N to 20° 54' N. It has a total geographical area of 8021 Sq Km with an average annual rainfall of 1597 mm (62.9). The average minimum and maximum temperatures are 1° in December to 35°C respectively (Jena *et al.*, 2016).

### Soil sampling and analysis

Soil samples were collected from two different depths (0-15cm and 15-30cm) of different villages of Balliguda, Nuagaon and Tumudibandha blocks of Kandhamal district of Odisha. From each block three different villages were selected for study. With the help of spade/garden hoe and khurpi soils were collected from crop fields by following v-shaped method. Samples were dried in shade and large clods were broken using wooden mallet. Using 2 mm sieve the powdered soils were sieved and were collected in a clean cloth or polythene bag and was labeled properly for laboratory analysis. A total no. of eighteen soil samples were collected from nine different villages along with latitude and longitude of the collected site by using GPS.

Soil samples were analyzed for its colour (by using Munsell colour chart), bulk density and particle density by Core method and Graduated measuring cylinder method respectively (by Muthuvel *et al.*, 1992 as described by Black, 1965), pH (1:2) (Jackson, 1958), EC (1:2) (Wilcox, 1950), organic carbon wet oxidation method (Walkley, 1947), available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by photoelectric colorimeter (Olson *et al.*, 1954), available potassium by flame photometer (Toth and Prince, 1949), available zinc by DTPA method (Lindsay and Norvell, 1969).

## Results and Discussion

### Soil colour

In dry condition, the reflection of soil colour from soils of two depths (0-15 cm & 15-30 cm) of different villages of Kandhamal district varied from brownish yellow (10YR 6/6) colour to yellowish brown (7.5YR 5/8) colour. And in wet condition, the soil colour

reflection varied from dark brown (10YR 3/3) colour to dark yellowish brown (10YR 4/4) colour. Variation in soil colour could be attributed to the varying water table in different land types (Digal *et al.*, 2018). Similar findings have also been observed by Digal *et al.*, (2018).

### **Bulk density and particle density of soil**

No significant difference was found in bulk density due to depth and due to village. The bulk density of soils of different villages varied from 1.11 to 1.33 g cm<sup>-3</sup>. The maximum mean bulk density of 1.29 g cm<sup>-3</sup> was found at V<sub>5</sub> – Balipada village and the minimum mean bulk density of 1.15 g cm<sup>-3</sup> was found at V<sub>1</sub> – Badeketa, V<sub>2</sub> – Budrukia, V<sub>4</sub> – Nuagaon and V<sub>8</sub> – Badagaon village. Increase in bulk density with depth was due to low organic matter and less aggregation. Similar findings were also reported by Sahoo *et al.*, (2015).

Whereas in particle density, no significant difference was found due to depth while a significant difference was found between villages. The particle density of soils from different villages varied from 2.22 to 3.33 g cm<sup>-3</sup>. The maximum mean particle density of 3.1 g cm<sup>-3</sup> was found at V<sub>1</sub> – Badeketa, V<sub>4</sub> – Nuagaon and V<sub>7</sub> – Tumudibandha village and the minimum mean bulk density of 2.22 g cm<sup>-3</sup> was found at V<sub>5</sub> – Balipada village. Particle density of soil was found to be in the range of medium to dense. Particle density varies according to the mineral content of the soil particles.

### **Soil reaction**

Significant difference was found in soil pH due to depth and due to village. The soil pH of different villages varied between 4 to 5.7. The maximum mean pH of 5.5 was found at V<sub>5</sub> – Balipada village and the minimum mean

pH of 4.2 was found at V<sub>7</sub> – Tumudibandha village.

Hence, the soil acidity appears to be a major crop production constraint in the study area (Digal *et al.*, 2018). Similar findings have also been reported earlier by Mishra *et al.*, (2014), Jena *et al.*, (2016), Subnudhi and Subudhi (2017) and Digal *et al.*, (2018).

### **Electrical Conductivity (dS m<sup>-1</sup>)**

Significant difference was found in electrical conductivity in soils due to depth and due to village. The soil EC at two depths of different villages varied between 0.1 to 0.23 dS m<sup>-1</sup>. The maximum mean EC of 0.22 dS m<sup>-1</sup> was found at V<sub>1</sub> – Badeketa village and the minimum mean EC of 0.03 dS m<sup>-1</sup> was found at V<sub>6</sub> – Kanjamendi and V<sub>9</sub> – Batabadi village. Soils of the study area were found to be non-saline in nature. Hence, all the soils under the study area are safe for all types of crop production with respect to the soluble salt content (Digal *et al.*, 2018). Similar findings have also been reported earlier by Mishra *et al.*, (2014), Jena *et al.*, (2016) and Digal *et al.*, (2018).

### **Organic carbon**

A significant difference was found in organic carbon content in soils due to depth whereas no significant difference was found in organic carbon content in soils between villages. Soil organic carbon content in soils of different villages varied between 0.54 to 1.25 %. The highest mean soil organic carbon content was found at V<sub>3</sub> – Lankamunda (0.94 %) and lowest mean soil organic carbon content was found at V<sub>7</sub> – Tumudibandha (0.56 %). Soil organic carbon status was found to be medium to high which enables the soil for higher crop production. Medium to higher organic carbon in the study area could be attributed to its presence in the bottom of

dense forest (Digal *et al.*, 2018). Similar findings have also been reported by Mishra *et al.*, (2014), Jena *et al.*, (2016), Subnudhi and Subudhi (2017) and Digal *et al.*, (2018).

**Available nitrogen**

A significant difference was found in available nitrogen in soils due to depth and due to village. Availability of nitrogen content in soils of different villages varied between 198.82 to 385.6 Kg ha<sup>-1</sup>. The highest mean

available nitrogen was found at V<sub>2</sub> –Budrukia (318.85 Kg ha<sup>-1</sup>) and lowest mean available nitrogen was found at V<sub>9</sub> – Batabadi (208.81Kg ha<sup>-1</sup>). The available nitrogen status in the entire study area was found to be low to medium. The reason may be attributed to the fact that nitrogen content is positively correlated with organic matter content which decreases with depth. Similar findings have also been reported by Mishra *et al.*, (2014), Dash *et al.*, (2018) and Digal *et al.*, (2018).

**Table.1** Soil sampling sites

Block	Village
Balliguda (B <sub>1</sub> )	Badeketa (V <sub>1</sub> )
	Budrukia (V <sub>2</sub> )
	Lankamunda (V <sub>3</sub> )
Nuagaon (B <sub>2</sub> )	Nuagaon (V <sub>4</sub> )
	Balipada (V <sub>5</sub> )
	Kanjamendi (V <sub>6</sub> )
Tumudibandha(B <sub>3</sub> )	Tumudibandha (V <sub>7</sub> )
	Badagan (V <sub>8</sub> )
	Batabadi (V <sub>9</sub> )

**Table.2** Bulk density and particle density in soils of different villages of Kandhamal District at two different depths

Village	Bulk density (g cm <sup>-3</sup> )			Particle density (g cm <sup>-3</sup> )		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
V <sub>1</sub>	1.11	1.18	1.15	2.86	3.33	3.1
V <sub>2</sub>	1.11	1.18	1.15	2.5	2.86	2.68
V <sub>3</sub>	1.18	1.25	1.22	2.5	2.22	2.36
V <sub>4</sub>	1.11	1.18	1.15	2.86	3.33	3.1
V <sub>5</sub>	1.25	1.33	1.29	2.22	2.22	2.22
V <sub>6</sub>	1.18	1.18	1.18	2.5	2.5	2.5
V <sub>7</sub>	1.18	1.25	1.22	2.86	3.33	3.1
V <sub>8</sub>	1.11	1.18	1.15	2.5	2.86	2.86
V <sub>9</sub>	1.18	1.25	1.22	2.5	2.22	2.36
<b>Mean</b>	1.16	1.22		2.59	2.76	
	<b>F-test</b>	<b>SEm(±)</b>	<b>CD at 5%</b>	<b>F-test</b>	<b>SEm(±)</b>	<b>CD at 5%</b>
<b>Due to depth</b>	NS	0.032	-	NS	0.785	-
<b>Due to village</b>	NS	0.017	-	S	0.116	0.020

**Table.3** Soil pH and Electrical conductivity (EC) in soils from different villages of Kandhamal District at two different depths

Village	pH			EC (dS m <sup>-1</sup> )		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
V <sub>1</sub>	4.3	4.7	4.5	0.23	0.2	0.22
V <sub>2</sub>	4.3	4.8	4.6	0.16	0.13	0.15
V <sub>3</sub>	4.4	4.8	4.6	0.05	0.03	0.04
V <sub>4</sub>	4.6	4.9	4.8	0.18	0.16	0.17
V <sub>5</sub>	5.7	5.33	5.5	0.14	0.12	0.13
V <sub>6</sub>	4.5	4.9	4.7	0.04	0.02	0.03
V <sub>7</sub>	4	4.4	4.2	0.11	0.1	0.11
V <sub>8</sub>	4.1	4.5	4.3	0.06	0.05	0.06
V <sub>9</sub>	4	4.5	4.3	0.04	0.02	0.03
Mean	4.4	4.8		0.11	0.09	
	<b>F-test</b>	<b>SEm(±)</b>	<b>CD at 5%</b>	<b>F-test</b>	<b>SEm(±)</b>	<b>CD at 5%</b>
<b>Due to depth</b>	S	0.163	0.007	S	0.01	0.00003
<b>Due to village</b>	S	0.132	0.003	S	0.023	0.000000002

**Table.4** Soil organic carbon in soils of different villages of Kandhamal District at two different depths

Village	Soil Organic carbon (%)		
	0-15 cm	15-30 cm	Mean
V <sub>1</sub>	0.83	0.62	0.73
V <sub>2</sub>	0.85	0.67	0.76
V <sub>3</sub>	1.25	0.62	0.94
V <sub>4</sub>	0.68	0.6	0.64
V <sub>5</sub>	0.69	0.66	0.68
V <sub>6</sub>	0.72	0.59	0.66
V <sub>7</sub>	0.57	0.54	0.56
V <sub>8</sub>	0.67	0.64	0.66
V <sub>9</sub>	0.67	0.62	0.65
Mean	0.77	0.62	
	<b>F-test</b>	<b>SEm(±)</b>	<b>CD at 5%</b>
<b>Due to depth</b>	S	0.076	0.044
<b>Due to village</b>	NS	0.036	-

**Table.5** Available nitrogen, phosphorus and potassium in soils of different villages of Kandhamal District at two different depths

Village	Available Nitrogen (Kg ha <sup>-1</sup> )			Available Phosphorus (Kg ha <sup>-1</sup> )			Available Potassium (Kg ha <sup>-1</sup> )		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
V <sub>1</sub>	330	262.6	296.3	53.1	50.26	51.68	161.6	96.47	129.04
V <sub>2</sub>	385.6	252.1	318.85	54.8	51.42	53.11	100.6	89	94.8
V <sub>3</sub>	322.05	252.1	287.08	45.56	42.81	44.19	101.7	86.42	94.06
V <sub>4</sub>	278.33	232.12	255.23	26.7	24.16	25.43	167.6	99.33	133.47
V <sub>5</sub>	266.4	260.7	263.55	27.32	24.22	25.77	134.1	122.5	128.3
V <sub>6</sub>	224.5	208.78	216.64	22.32	20.84	21.73	100.3	90.55	95.43
V <sub>7</sub>	262.6	252.1	257.35	25.4	24.7	24.12	101.3	96.75	99.03
V <sub>8</sub>	222.6	206.9	214.75	22.6	20.34	21.3	112.2	93.2	102.7
V <sub>9</sub>	218.8	198.82	208.81	21.34	18.76	19.89	121.2	82.23	101.72
Mean	278.99	236.25		37.4	34.2		122.29	95.16	
	F-test	SEm(±)	CD at 5%	F-test	SEm(±)	CD at 5%	F-test	SEm(±)	CD at 5%
Due to depth	S	21.37	0.015	S	1.20	0.00003	S	13.56	0.010
Due to village	S	12.94	0.05	S	4.53	0.00000000003	NS	5.49	-

**Table.6** Available zinc and sulphur in soils of different villages of Kandhamal District at two different depths

Village	Available Zinc (ppm)			Available Sulphur (ppm)		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
V <sub>1</sub>	0.37	0.56	0.47	2.77	3.7	3.24
V <sub>2</sub>	0.58	0.33	0.46	0.37	0.18	0.28
V <sub>3</sub>	0.35	0.18	0.27	2.59	2.77	2.68
V <sub>4</sub>	0.4	0.85	0.63	3.7	2.22	2.96
V <sub>5</sub>	0.37	0.59	0.48	2.96	2.4	2.68
V <sub>6</sub>	0.59	0.77	0.68	2.59	2.75	2.67
V <sub>7</sub>	0.33	0.59	0.46	3.7	2.59	3.15
V <sub>8</sub>	0.96	0.4	0.68	2.96	2.4	2.68
V <sub>9</sub>	0.7	0.22	0.46	3.34	2.22	2.78
Mean	0.52	0.5		2.78	2.36	
	F-test	SEm(±)	CD at 5%	F-test	SEm(±)	CD at 5%
Due to depth	NS	0.009	-	NS	0.208	-
Due to village	NS	0.044	-	S	0.295	0.014

**Available phosphorus**

A significant difference was found in available phosphorus in soils due to depth and

due to village. Availability of phosphorus content in soils of different villages varied between 20.34 to 54.11 Kg ha<sup>-1</sup>. The highest mean available phosphorus was found at V<sub>2</sub> –

Budrukia ( $53.11 \text{ Kg ha}^{-1}$ ) and lowest mean available phosphorus was found at V<sub>8</sub> – Badagan ( $21.3 \text{ Kg ha}^{-1}$ ). The available phosphorus status in the entire study area was found to be medium to high. Similar findings have also been reported by Mishra *et al.*, (2014), Dash *et al.*, (2018) and Digal *et al.*, (2018).

### **Available potassium**

A significant difference was found in available potassium in soils due to depth and no significant difference was found in available potassium in soils between villages. Availability of potassium content in soils of different villages varied between 82.23 to  $167.6 \text{ Kg ha}^{-1}$ . The highest mean available potassium was found at V<sub>4</sub> – Nuagaon ( $133.47 \text{ Kg ha}^{-1}$ ) and lowest mean available potassium was found at V<sub>3</sub> –Lankamunda ( $94.06 \text{ Kg ha}^{-1}$ ).

The available potassium status in the entire study area was found to be low to medium. The highest K content observed in the surface horizon and showed more or less decreasing trend with depth. This might be attribute to more intense weathering and release of liable K from organic residues. Similar findings have also been reported by Mishra *et al.*, (2014), Dash *et al.*, (2018) and Digal *et al.*, (2018).

### **Available zinc**

No significant difference was found in available zinc in soils due to depth and due to village. Availability of zinc in soils of different villages at two different depths varied from 0.18 to 0.96 ppm. The highest mean available zinc was found at V<sub>6</sub> - Kanjamendi and V<sub>8</sub> - Badagan (0.68 ppm) and lowest mean available zinc was found at V<sub>3</sub> – Lankamunda (0.27 ppm). Zn deficiency was observed in all blocks of the district (Jena *et*

*al.*, 2016). Similar result was reported by Jena *et al.*, (2016).

### **Available sulphur**

No significant difference was found in available zinc in soils due to depth while a significant difference was found in available zinc in soils between villages. Availability of sulphur content in soils varied from 0.18 to 3.7 ppm. The highest mean available sulphur was found at V<sub>1</sub> – Badeketa (3.24 ppm) and lowest mean available sulphur was found at V<sub>2</sub> –Budrukia (0.28 ppm).

High deficiency of S in Kandhamal soils might be attributed to high altitude upland (Alfisols) leading to leaching of anionic nutrients (Jena *et al.*, 2016). Available sulphur was found to be in the range of low to medium (Digal *et al.*, 2018). Similar results were observed by Mishra *et al.*, (2014) Jena *et al.*, (2016) and Digal *et al.*, (2018).

Above data shows that the physical properties like soil colour and bulk density are within normal range of parameters. Particle density of soils was found to be medium to dense. Whereas pH value of soil samples shows that most of them are acidic in nature and soil EC value shows that most of them are is of non-saline in nature. The soil organic carbon and available phosphorus content of these soils were found to be medium to high whereas available nitrogen and available potassium content in these soils were found to be low to medium. Zinc deficiency was observed in these soils. The available sulphur in these soils were found to be in low to medium range.

Therefore 25 percent more nitrogenous and potassic fertilizers should be applied than that of the recommended dose of the same in the fields having lower range of nitrogen and potassium status and 25 percent less

phosphatic fertilizers should be applied than that of the recommended dose of the same in those fields having higher in potassium status. Since most soils show sulphur and zinc deficiency, 25 percent more zinc and sulphur containing fertilizers should be applied than that of the recommended dose of the same in those fields having lower range of zinc and sulphur status.

In conclusion the major crop production constraint in the study area was found to be soil acidity. Due to soil erosion and water logging, most of the soils were found to be deficient in available nitrogen, potassium, zinc and sulphur content. So, application of liming materials along with application of soil test based nitrogenous, potassic, zinc and sulphur containing fertilizers and manures will help to obtain higher crop production as well as sustaining soil health.

Hence, it is concluded that to obtain better soil health and soil quality a more attention is needed to pay in the role of macronutrient enhancement in the soil which will lead to optimum economic yield. And for maintaining soil health and soil quality adoption of organic farming will be an essential step.

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