

# Chapter 2

## Soil Sampling and Analysis

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Soil sampling is one of the most important prerequisites to implement site-specific nutrient management. It is also the weakest link in the whole chain of soil test-based nutrient management. A small quantity of soil (about 500 g) collected should truly represent the millions of tons of soil in a field. Hence, utmost care should be taken during collection to secure accurate results.

### Stratified soil sampling

In order to diagnose soil fertility-related constraints, about 40,265 soil samples were collected from farmers' fields across 30 districts of Odisha. Stratified soil sampling method (Sahrawat et al. 2008, 2011; Chander et al. 2013) was adopted, wherein 10% of the villages that are representative of the agro-climate of a block were selected and 10 soil samples were collected from each village. The target village was divided into three toposes, and at each topose, samples were drawn proportionately representing different farm sizes, soil colour, texture, cropping system and land management practices. In each soil sample collected in each farmer's field, 8 to 10 cores of soil from a depth of 0–0.15 cm were collected and mixed together to make a composite sample. All the samples were collected during pre-monsoon season, i.e., April to June 2018. Details of the samples collected district-wise and block-wise are given in Table 2.1 and Annexure 1, respectively.

### Soil sample preparation and analysis

Under the Odisha *Bhoochetana* project, 40,265 geo-referenced soil samples were collected from different farmer's fields across 30 districts. The sample bags were properly tagged, labelled and transferred to the ICRISAT processing unit. The soil samples were air dried and the clods ground using a wooden mortar and pestle. The sample was then passed through a 2 mm sieve. For organic carbon analysis, the samples were further ground and passed through a 0.25 mm sieve. The processed samples were analyzed for 13 chemical parameters in ICRISAT's Charles Renard Analytical Laboratory.

For soil analysis, pH was measured by a glass electrode using a soil-water suspension in the ratio of 1:2 (Thomas 1996) and EC was measured with the same suspension after settling the sample overnight using an EC meter (Rhoades 1996). Organic carbon was determined using the Walkley-Black method (Nelson and Sommers, 1996). Exchangeable bases, i.e., K, Ca and Mg were determined using neutral normal ammonium acetate method (Okalebo et al. 1993). Available P was estimated using Brays Extractant No. 1, 0.03M  $\text{NH}_4\text{F}$  in 0.025M HCl (Bray and Kurtz, 1945) for acidic soils and sodium bicarbonate ( $\text{NaHCO}_3$ ) of pH 8.5 as an extractant (Olsen and Sommers, 1982) in the case of alkaline soils. Available micronutrients, i.e., Fe, Cu, Mn and Zn were extracted by DTPA reagent of pH 7.3 (Lindsay and Norvell, 1978) and available B was extracted by hot water (Keren 1996). Available S was measured using 0.15% calcium chloride ( $\text{CaCl}_2$ ) as an extractant (Tabatabai 1996). Macro and micronutrients were measured on Microwave Plasma Atomic Emission Spectroscopy whereas, Boron and Sulphur were measured through the Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES).

**Table 2.1. Details of the district-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Number of blocks</b>	<b>Number of villages</b>	<b>Number of soil samples collected</b>
Angul	8	104	1020
Baleswar	12	156	1550
Bargarh	12	156	1550
Bhadrak	7	91	910
Balangir	14	182	1819
Boudh	3	39	370
Cuttak	14	182	1820
Deogarh	3	39	390
Dhenkanal	8	104	1030
Gajapati	7	91	939
Ganjam	22	286	2810
Jagatsinghpur	8	104	1040
Jajpur	10	130	1300
Jharsuguda	5	65	650
Kalahandi	13	169	1670
Kandhamal	12	156	1554
Kendrapara	9	117	1150
Kendujhar	13	169	1540
Khorda	10	130	1300
Koraput	11	182	1769
Malkangiri	6	91	937
Mayurbhanj	26	338	3317
Nabarangpur	10	130	1213
Nayagarh	8	104	1040
Nuapada	5	65	647
Puri	11	143	1420
Rayagada	10	143	1430
Sambalpur	9	117	1170
Subarnapur	6	78	780
Sundargarh	17	221	2130
<b>Total</b>	<b>309</b>	<b>4082</b>	<b>40,265</b>

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## Annexure

**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

District	Block	Number of villages chosen for sampling	Number of soil samples collected
Angul	Angul	15	150
Angul	Athamallik	15	130
Angul	Banarpal	9	90
Angul	Chendipada	10	100
Angul	Kanhia	15	150
Angul	Kishorenagar	15	150
Angul	Pallahara	15	150
Angul	Talcher	10	100
<b>Total</b>	<b>8</b>	<b>104</b>	<b>1020</b>
Baleswar	Bahanoga	10	100
Baleswar	Baleswar	15	150
Baleswar	Baliapal	15	150
Baleswar	Basta	10	100
Baleswar	Bhogarai	16	160
Baleswar	Jaleswar	15	150
Baleswar	Khaira	20	200
Baleswar	Nilagiri	10	100
Baleswar	Oupada	10	100
Baleswar	Remuna	15	140
Baleswar	Simulia	10	100
Baleswar	Soro	10	100
<b>Total</b>	<b>12</b>	<b>156</b>	<b>1550</b>
Bargarh	Ambabhona	16	160
Bargarh	Atabira	15	150
Bargarh	Bargarh	10	90
Bargarh	Barpali	10	100
Bargarh	Bhatli	10	100
Bargarh	Bheden	10	100
Bargarh	Bijepur	15	150
Bargarh	Gaisilat	10	100
Bargarh	Jharbandh	10	100
Bargarh	Padmapur	20	200
Bargarh	Paikamal	15	150
Bargarh	Sohella	15	150
<b>Total</b>	<b>12</b>	<b>156</b>	<b>1550</b>

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Bhadrak	Basudevpur	15	150
Bhadrak	Bhadrak	10	100
Bhadrak	Bhandaripokhari	12	120
Bhadrak	Bonth	15	150
Bhadrak	Chandabali	15	150
Bhadrak	Dhamanagar	12	120
Bhadrak	Tihidi	12	120
<b>Total</b>	<b>7</b>	<b>91</b>	<b>910</b>
Balangir	Agalapur	10	100
Balangir	Bangamunda	15	150
Balangir	Belapada	10	100
Balangir	Balangir	12	120
Balangir	Deogam	15	149
Balangir	Gudvella	10	100
Balangir	Kaprakhole	15	150
Balangir	Lusinga	10	100
Balangir	Muribahal	15	150
Balangir	Patnagarh	15	150
Balangir	Puintala	15	150
Balangir	Saintala	15	150
Balangir	Titilagarh	15	150
Balangir	Turekela	10	100
<b>Total</b>	<b>14</b>	<b>182</b>	<b>1819</b>
Boudh	Boudh	14	130
Boudh	arbhangra	10	90
Boudh	Kantamal	15	150
Total	3	39	370
Cuttack	Athagarh	20	200
Cuttack	Banki	12	120
Cuttack	Banki-Dampada	10	100
Cuttack	Baramba	5	50
Cuttack	Baranga	8	80
Cuttack	Choudwar	16	160
Cuttack	Cuttack Sadar	10	100
Cuttack	Kantapada	10	100

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Cuttack	Mahanga	20	200
Cuttack	Narasinghpur	20	200
Cuttack	Niali	10	100
Cuttack	Nischantakoili	20	200
Cuttack	Salepur	16	160
Cuttack	Tigiria	5	50
<b>Total</b>	<b>14</b>	<b>182</b>	<b>1820</b>
Deogarh	Barkote	9	90
Deogarh	Reamal	20	200
Deogarh	Tileibani	10	100
<b>Total</b>	<b>3</b>	<b>39</b>	<b>390</b>
Dhenkanal	Bhuban	10	100
Dhenkanal	Dhenkanal (Sadar)	15	150
Dhenkanal	Gondia	15	150
Dhenkanal	Hindol	15	150
Dhenkanal	Kamakhyanagar	10	100
Dhenkanal	Kankadahad	14	140
Dhenkanal	Odapada	10	100
Dhenkanal	Parjang	15	140
<b>Total</b>	<b>8</b>	<b>104</b>	<b>1030</b>
Gajapati	Gumma	15	150
Gajapati	Kasinagar	10	80
Gajapati	Mohana	20	190
Gajapati	Nuagada	12	159
Gajapati	Paralakhemundi	10	100
Gajapati	Udayagiri	12	140
Gajapati	7. Rayagada	12	120
<b>Total</b>	<b>7</b>	<b>91</b>	<b>939</b>
Ganjam	Aska	10	100
Ganjam	Beguniapada	15	150
Ganjam	Belguntha	10	80
Ganjam	Bhanjanagar	15	150
Ganjam	Buguda	10	100
Ganjam	Chatrapur	10	100
Ganjam	Chikiti	10	100

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Ganjam	Dharakote	16	160
Ganjam	Digipahandi	20	200
Ganjam	Ganjam	10	100
Ganjam	Hinjilikatu	5	50
Ganjam	Jagannath Prasad	25	250
Ganjam	Kabisuryanagar	5	50
Ganjam	Khallikote	10	100
Ganjam	Kukudakhandi	10	100
Ganjam	Patrapur	25	250
Ganjam	Polsara	10	100
Ganjam	Purusottampur	10	100
Ganjam	Rangeilunda	10	100
Ganjam	Sanakhemundi	10	100
Ganjam	Sheragada	10	100
Ganjam	Sorada	30	270
<b>Total</b>	<b>22</b>	<b>286</b>	<b>2810</b>
Jagatsinghpur	Balikuda	20	200
Jagatsinghpur	Biridi	8	80
Jagatsinghpur	Ersama	15	150
Jagatsinghpur	Jagatsinghpur	15	150
Jagatsinghpur	Kujang	10	100
Jagatsinghpur	Naugaon	8	80
Jagatsinghpur	Raghunathpur	8	80
Jagatsinghpur	Tirtol	20	200
<b>Total</b>	<b>8</b>	<b>104</b>	<b>1040</b>
Jajpur	Barchana	15	150
Jajpur	Bari	10	100
Jajpur	Binjharpur	10	100
Jajpur	Dangadi	10	100
Jajpur	Dasarathpur	15	150
Jajpur	Dharmasala	15	150
Jajpur	Jajpur	15	150
Jajpur	Korei	15	150
Jajpur	Rasulpur	15	150
Jajpur	Sukinda	10	100

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
<b>Total</b>	<b>10</b>	<b>130</b>	<b>1300</b>
Jharsuguda	Jharsuguda	15	150
Jharsuguda	Kirmira	10	100
Jharsuguda	Kolabira	10	100
Jharsuguda	Laikera	10	100
Jharsuguda	Lakhanpur	20	200
<b>Total</b>	<b>5</b>	<b>65</b>	<b>650</b>
Kalahandi	Bhawanipatna	20	200
Kalahandi	Dharmagarh	10	100
Kalahandi	Golamunda	10	100
Kalahandi	Jaipatna	8	80
Kalahandi	Junagarh	15	150
Kalahandi	Kalampur	5	50
Kalahandi	Karlamunda	6	60
Kalahandi	Kesinga	10	90
Kalahandi	Koksara	7	70
Kalahandi	Lanjigarh	25	240
Kalahandi	Madanpur Rampur	25	250
Kalahandi	Narla	10	100
Kalahandi	Thuamul Rampur	18	180
<b>Total</b>	<b>13</b>	<b>169</b>	<b>1670</b>
Kandhamal	Balliguda	15	149
Kandhamal	Chakapad	10	100
Kandhamal	Daringbadi	15	140
Kandhamal	G.Udayagiri	10	100
Kandhamal	K.Nuagaon	10	100
Kandhamal	Khajuripada	15	150
Kandhamal	Kotgarh	10	100
Kandhamal	Phiringia	20	199
Kandhamal	Phulbani	15	150
Kandhamal	Raikia	11	110
Kandhamal	Tikabali	10	106
Kandhamal	Tumudibandh	15	150
<b>Total</b>	<b>12</b>	<b>156</b>	<b>1554</b>

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Kendrapara	Aul	10	100
Kendrapara	Derabish	15	140
Kendrapara	Garadpur	10	100
Kendrapara	Kendrapara	10	100
Kendrapara	Mahakalapara	20	200
Kendrapara	Marsaghai	10	100
Kendrapara	Pattamundai	10	100
Kendrapara	Rajkanika	10	90
Kendrapara	Rajnagar	22	220
<b>Total</b>	<b>9</b>	<b>117</b>	<b>1150</b>
Kendujhar	Anandapur	12	120
Kendujhar	Bansalpal	15	150
Kendujhar	Champua	12	120
Kendujhar	Ghasipura	12	120
Kendujhar	Ghatgaon	11	110
Kendujhar	Harichandanpur	20	200
Kendujhar	Hatadihi	15	150
Kendujhar	Jhumpura	12	120
Kendujhar	Joda	10	50
Kendujhar	Kendujhar (Sadar)	20	100
Kendujhar	Patna	10	100
Kendujhar	Saharapada	10	100
Kendujhar	Telkoi	10	100
<b>Total</b>	<b>13</b>	<b>169</b>	<b>1540</b>
Khorda	Balianta	10	100
Khorda	Balipatna	12	120
Khorda	Banapur	15	150
Khorda	Begunia	15	150
Khorda	Bhubaneswar	10	100
Khorda	Bolagad	20	200
Khorda	Chilika	13	130
Khorda	Jatni	10	100
Khorda	Khorda	10	100
Khorda	Tangii	15	150
<b>Total</b>	<b>10</b>	<b>130</b>	<b>1300</b>

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Koraput	Bandhugaon	15	
Koraput	Boipariguda	20	
Koraput	Boriguma	15	220
Koraput	Dasamanthpur	16	60
Koraput	Jeypore	10	100
Koraput	Koraput	10	140
Koraput	Kotpad	10	210
Koraput	Kundra	10	100
Koraput	Lamptaput	16	189
Koraput	Laxmipur	10	100
Koraput	Nandapur	20	450
Koraput	Narayanapatna	10	
Koraput	Pottangi	10	100
Koraput	Semiliguda	10	100
	<b>Total</b>	<b>182</b>	<b>1769</b>
Malkangiri	Kallimela	15	129
Malkangiri	Khairaput	10	100
Malkangiri	Korukonda	15	148
Malkangiri	Kudmulgumma	15	300
Malkangiri	Malkangiri	10	
Malkangiri	Mathili	20	200
Malkangiri	Podia	6	60
<b>Total</b>	<b>7</b>	<b>91</b>	<b>937</b>
Mayurbhanj	Badasahi	20	200
Mayurbhanj	Bahalda	10	90
Mayurbhanj	Bangiriposhi	20	200
Mayurbhanj	Baripada	10	100
Mayurbhanj	Betanati	25	250
Mayurbhanj	Bijatala	10	100
Mayurbhanj	Bisoi	15	150
Mayurbhanj	Gopabandhunagar	10	100
Mayurbhanj	Jamda	5	50
Mayurbhanj	Joshipur	20	200
Mayurbhanj	Kaptipada	10	100
Mayurbhanj	Karanjia	15	140
Mayurbhanj	Khunta	10	100

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Mayurbhanj	Kuliana	20	200
Mayurbhanj	Kusumi	10	99
Mayurbhanj	Moroda	15	150
Mayurbhanj	Rairangapur	10	90
Mayurbhanj	Raruan	10	100
Mayurbhanj	Rasagobindapur	15	150
Mayurbhanj	Samakhunta	10	99
Mayurbhanj	Sarasakana	15	150
Mayurbhanj	Sukuruli	8	79
Mayurbhanj	Suliapada	20	170
Mayurbhanj	Thakurmunda	15	150
Mayurbhanj	Tiring	5	50
Mayurbhanj	Udala	5	50
<b>Total</b>	<b>26</b>	<b>338</b>	<b>3317</b>
Nabarangpur	Chandahandi	10	100
Nabarangpur	Dabugaon	15	148
Nabarangpur	Jharigaon	10	101
Nabarangpur	Kosagumuda	15	119
Nabarangpur	Nandahandi	10	88
Nabarangpur	Nabarangpur	10	100
Nabarangpur	Papadahandi	10	100
Nabarangpur	Raighar	20	161
Nabarangpur	Tentulikhunti	20	198
Nabarangpur	Umerkote	10	98
<b>Total</b>	<b>10</b>	<b>130</b>	<b>1213</b>
Nayagarh	Bhapur	10	100
Nayagarh	Daspalla	20	200
Nayagarh	Gania	10	100
Nayagarh	Khandapada	12	120
Nayagarh	Nayagarh	10	100
Nayagarh	Nuagaon	12	120
Nayagarh	Odagaon	15	150
Nayagarh	Ranpur	15	150
<b>Total</b>	<b>8</b>	<b>104</b>	<b>1040</b>

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Nuapada	Boden	10	100
Nuapada	Khariar	10	100
Nuapada	Komna	15	150
Nuapada	Nuapada	15	147
Nuapada	Sinapali	15	150
<b>Total</b>	<b>5</b>	<b>65</b>	<b>647</b>
Puri	Astarang	10	100
Puri	Brahmagiri	15	150
Puri	Delang	10	90
Puri	Gop	15	150
Puri	Kakatpur	10	100
Puri	Kanas	15	150
Puri	Krushnaprasad	10	100
Puri	Nimapada	18	180
Puri	Pipili	15	150
Puri	Puri Sadar	10	100
Puri	Satyabadi	15	150
<b>Total</b>	<b>11</b>	<b>143</b>	<b>1420</b>
Rayagada	Bissamcuttack	10	130
Rayagada	Chandrapur	10	100
Rayagada	Gudari	10	100
Rayagada	Gunupur	20	190
Rayagada	Kalyansinghpur	13	130
Rayagada	Kashipur	20	200
Rayagada	Kolanara	10	100
Rayagada	Muniguda	20	200
Rayagada	Ramanaguda	10	
Rayagada	Rayagada	20	180
Rayagada	Padmapur		100
<b>Total</b>	<b>11</b>	<b>143</b>	<b>1430</b>
Sambalpur	Bamara	15	150
Sambalpur	Dhankauda	10	100
Sambalpur	Jamanakira	25	250
Sambalpur	Jujomora	10	100
Sambalpur	Kuchinda	10	100

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**Annexure 1. Details of block-wise soil sampling done across 30 districts in Odisha.**

<b>District</b>	<b>Block</b>	<b>Number of villages chosen for sampling</b>	<b>Number of soil samples collected</b>
Sambalpur	Maneswar	10	100
Sambalpur	Naktideul	15	150
Sambalpur	Rairakhol	15	150
Sambalpur	Rengali	7	70
<b>Total</b>	<b>9</b>	<b>117</b>	<b>1170</b>
Subarnapur	Binka	9	90
Subarnapur	Birmaharajpur	13	130
Subarnapur	Dunguripalli	10	100
Subarnapur	Subarnapur	12	120
Subarnapur	Tarva	14	140
Subarnapur	Ulunda	20	200
<b>Total</b>	<b>6</b>	<b>78</b>	<b>780</b>
Sundargarh	Badagaon	10	100
Sundargarh	Balisankara	10	100
Sundargarh	Banaigarh	16	100
Sundargarh	Bisra	10	300
Sundargarh	Gurundia	20	10
Sundargarh	Hemgiri	15	240
Sundargarh	Koira	10	10
Sundargarh	Kuanrmunda	25	250
Sundargarh	Kutra	20	190
Sundargarh	Lahunipada	20	200
Sundargarh	Lathikata	10	100
Sundargarh	Lephripara	15	130
Sundargarh	Rajgangpur	10	100
Sundargarh	Subdega	10	100
Sundargarh	Sundargarh (Sadar)	10	100
Sundargarh	Tangarpalli	10	100
<b>Total</b>	<b>17</b>	<b>221</b>	<b>2130</b>