

# **Final Report**

on

Research on the Distribution of Soil Chemistry and  
Fe Dynamics in Sanjian Plain for 2006

by

Institute of Applied Ecology,  
Chinese Academy of Sciences

# Final Report of Joint Research on Distribution of Soil Chemistry and Fe Dynamics in Sanjian Plain for 2006

## **1. Main contents and accomplishment of our work**

1.1 Soil samples were collected from marsh soil and albic soil in 2006 at several locations between Naoli River and Nonjiang River, including four land covers, *i.e.*, natural wetland, paddy field, upland field, and forest. The sampling was carried out in duplicate per each location with soil coring kit, and the total number of sampling sites was 32.

Soil samples were collected vertically from surface to a depth of 1.2 meters. The soil profile was divided into 7 layers, *i.e.*, 0-10cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-60 cm, 60-90 cm and 90-120 cm, and the total number of soil samples was 224.

Some appropriate measures were adopted to ensure the sampling work and analysis to be accurately.

- 1) GPS technology was used to provide precise geographical positioning.
- 2) Fresh soil samples were stored in thin wall PVC tubes (transparent, 50X300mm, with lid and bottom, and made by Eijkelkamp) at 0 ~ 4°C to prevent oxygenation during transportation and storage.
- 3) The collected soil samples were 1mm- and 0.25 mm- sieved with prior drying by using polyethylene sieve to avoid metal contamination.

The main content and accomplishment of our work are shown in the following tables in detail.

## **2. Correlative problems in the research, which should be improved next year**

2.1 According to the contract, water-soluble iron should be quantified in this year. We did it by the method from “Methods of Soil Analysis Part 3 - Chemical Methods”, but failed. A discussion would be made with Professor Yoh and Dr. Shibata about the details of treating soil samples.

2.2 To further study the effects of land use type on various forms of Fe, acid-leachable and alumino-silicate Fe should be added. In addition, soil dissolved organic carbon (DOC) should be determined, which might have remarkable effects on soil dissolved Fe.

### 3. Pictures of sampling and analysis in this fiscal year



**Table.1: Sampling sites in Sanjiang Plain region**

No.	Location	Soil type	Land use type	Reclamation history
Region 1	47°16.152'N, 133°45.797'E		Wetland	Without reclamation
Region 2	47°17.122'N, 133°46.110'E		Wetland	Without reclamation
Region 3	47°31.706'N, 133°52.871'E		Paddy field	5 years
Region 4	47°17.122'N, 133°46.076'E	Marsh soil	Paddy field	23 years
Region 5	47°25.825'N, 133°52.517'E		Forest	Without reclamation
Region 6	47°25.635'N, 133°52.577'E		Forest	Without reclamation
Region 7	47°31.708'N, 133°52.872'E		Upland field	5 years
Region 8	47°17.073'N, 133°45.877'E		Upland field	23 years
Region 9	47°35.269'N, 133°30.146'E		Wetland	Without reclamation
Region 10	47°44.244'N, 133°31.212'E		Wetland	Without reclamation
Region 11	47°44.216'N, 133°30.580'E		Paddy field	2 years
Region 12	47°39.479'N, 133°30.471'E	Albic soil	Paddy field	11 years
Region 13	47°23.082'N, 133°52.537'E		Forest	Without reclamation
Region 14	47°22.633'N, 133°52.503'E		Forest	Without reclamation
Region 15	47°44.482'N, 133°31.253'E		Upland field	4 years
Region 16	47°44.236'N, 133°30.625'E		Upland field	15 years

**Table.2: Analytical items and methods, and soil treatments**

No.	Items	Soil treatment	Analytical method
1	Fe <sup>2+</sup>	Fresh	Phenanthroline colorimetry
2	Mn <sup>2+</sup>	Fresh	Potassium periodate colorimetry
3	TOC (Total organic carbon)	Drying, sieving	Determined directly on the TOC autoanalyzer
4	pH (H <sub>2</sub> O)	Air-dry, sieving	Potentiometric method
5	pH (KCl)	Air-dry, sieving	Potentiometric method
6	Ferric chelate	Drying, sieving	Sodium pyrophosphate extraction method
7	Free iron oxide	Drying, sieving	Sodium hydrosulfite - Sodium citrate - Sodium bicarbonate extraction method (DCB)
8	Ca <sup>2+</sup>	Air-dry, sieving	EDTA complexometric titration
9	Mg <sup>2+</sup>	Air-dry, sieving	EDTA complexometric titration
10	Cl <sup>-</sup>	Air-dry, sieving	Silver nitrate titration
11	SO <sub>4</sub> <sup>2-</sup>	Air-dry, sieving	EDTA indirect titrimetric method
12	K <sup>+</sup>	Air-dry, sieving	Flame photometry
13	Na <sup>+</sup>	Air-dry, sieving	Flame photometry
14	Fe	Drying, sieving	Sodium carbonate fusion—Inductively Coupled Plasma(ICP)
15	Mn	Drying, sieving	Sodium carbonate fusion—Inductively Coupled Plasma(ICP)
16	Al	Drying, sieving	Sodium carbonate fusion—Potassium fluoride substitution—EDTA volumetric method
17	Si	Drying, sieving	Sodium carbonate fusion—Mass metrical method
18	Moisture content (%)	Air-dry	Mass metrical method

**Table.3: Analytical results for region 1 (Marsh soil, wetland)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	44.18	31.71	29.36	29.37	23.08	21.05	10.82
	37.64	34.30	30.73	31.10	23.75	26.73	14.01
pH (H <sub>2</sub> O)	5.61	6.68	6.84	7.03	6.91	7.02	6.91
	5.61	6.62	6.77	5.11	4.90	6.79	7.08
pH (KCl)	4.82	5.25	5.40	5.35	5.27	5.25	5.22
	4.91	5.18	5.32	3.91	3.44	4.89	5.08
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	9.72	4.04	2.58	2.01	7.11	9.15	5.63
	14.59	11.57	12.20	15.13	10.59	7.67	3.07
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	0.82	0.56	0.89	0.33	0.37	0.39	0.44
	0.84	0.79	0.63	5.70	4.21	0.49	0.54
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	19.24	16.16	10.05	8.86	10.17	9.76	9.54
	38.40	13.23	9.80	152.68	122.71	14.88	9.85
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	12.20	4.01	4.65	4.55	3.90	4.97	4.27
	5.64	11.39	9.23	42.50	44.43	6.33	2.34
Al (g.kg <sup>-1</sup> )	126.97	50.80	79.56	62.39	62.52	48.86	97.54
	92.90	120.15	77.55	96.32	118.87	106.33	98.83
Si (g.kg <sup>-1</sup> )	341.40	265.95	326.50	307.64	329.21	616.26	687.54
	529.61	560.56	514.91	253.15	577.28	632.80	914.83
K <sup>+</sup> (mg.kg <sup>-1</sup> )	15.56	6.19	6.19	6.19	9.46	7.49	18.35
	6.19	6.19	6.19	8.80	6.19	8.14	7.49
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	69.58	41.31	30.21	27.57	14.64	11.79	71.29
	34.27	22.46	23.09	24.35	14.64	23.72	13.49
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	30.81	33.61	12.14	13.07	13.54	31.28	23.34
	60.69	23.34	13.54	11.67	8.87	14.47	18.21
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.26	0.25	0.17	0.30	0.18	0.22	0.23
	0.22	0.14	0.28	0.22	0.19	0.20	0.07
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	19.83	28.84	27.04	1.20	37.25	87.71	15.62
	37.85	39.05	39.52	15.02	6.01	1.20	12.02
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	84.11	34.04	36.05	71.09	75.10	44.06	73.09
	71.09	40.05	37.05	41.05	40.05	55.07	32.04
TOC (%)	6.17	2.29	1.29	0.67	0.28	0.13	0.05
	6.88	1.45	1.04	10.15	2.88	0.18	0.00
Mn (g.kg <sup>-1</sup> )	0.04	0.02	0.04	0.04	0.02	0.10	0.05
	0.06	0.03	0.04	0.08	0.06	0.14	0.05
Fe (g.kg <sup>-1</sup> )	19.29	11.39	30.94	32.71	11.65	21.58	11.60
	23.41	27.04	38.39	26.82	27.88	27.28	11.51

**Table.4: Analytical results for region 2 (Marsh soil, wetland)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	45.33	34.69	23.87	20.78	23.37	22.65	21.17
pH (H <sub>2</sub> O)	30.69	37.59	29.64	27.12	30.35	39.81	17.46
pH (KCl)	5.04	5.18	5.17	6.95	7.06	4.73	4.76
	5.19	5.31	5.02	5.19	5.27	4.96	5.01
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	4.42	4.66	4.2	5.31	5.28	3.19	3.3
	4.38	4.34	4.35	4.33	4.12	3.78	3.35
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	12.29	10.57	13.91	6.62	7.18	34.50	38.31
	9.73	9.10	13.01	12.91	19.17	20.28	22.68
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	7.06	8.05	9.62	0.51	0.48	2.21	3.66
	4.79	7.51	8.38	9.05	9.78	6.15	3.08
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	114.84	103.33	84.37	9.21	12.05	144.57	129.99
	83.92	76.85	76.08	143.38	158.92	173.69	115.49
Al (g.kg <sup>-1</sup> )	19.73	21.18	50.14	4.62	1.75	26.39	40.98
	7.97	13.81	34.08	72.28	77.47	48.38	30.31
Si (g.kg <sup>-1</sup> )	56.32	22.56	38.80	113.48	52.68	60.55	97.08
	29.41	14.97	19.35	129.39	20.40	77.49	72.52
K <sup>+</sup> (mg.kg <sup>-1</sup> )	332.25	154.24	240.86	557.81	580.89	386.55	571.98
	194.89	101.26	99.74	483.46	288.72	593.59	518.17
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	17.50	30.05	18.35	7.49	8.80	7.49	7.49
	14.87	12.14	14.18	14.18	8.80	8.80	7.49
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	59.66	68.64	56.46	32.90	27.57	13.49	12.92
	50.23	42.77	31.55	64.56	58.05	27.57	12.92
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	25.15	24.55	21.42	23.81	13.54	10.27	14.47
	28.26	24.20	22.63	25.65	28.48	19.14	25.21
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	0.14	0.09	0.09	0.14	0.12	0.06	0.10
	0.10	0.18	0.15	0.20	0.16	0.09	0.18
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	22.92	25.63	50.2	46.26	16.82	9.61	16.82
	56.22	33.25	62.52	45.26	16.53	17.42	86.51
TOC (%)	25.6	33.10	25.62	44.06	55.07	32.04	30.04
	26.8	55.6	28.56	0.00	0.00	45.06	27.04
Mn (g.kg <sup>-1</sup> )	19.90	30.51	21.60	0.67	0.31	0.94	1.10
	16.72	25.32	30.77	32.05	26.49	8.17	1.03
Fe (g.kg <sup>-1</sup> )	0.10	0.06	0.09	0.05	0.08	0.06	0.05
	0.12	0.09	0.08	0.17	0.09	0.12	0.13
	19.29	13.66	17.88	35.26	30.28	31.14	46.81
	19.66	15.66	13.13	39.38	21.29	36.26	42.93

**Table.5: Analytical results for region 3 (Marsh soil, paddy field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	43.05	26.96	21.98	24.65	27.63	24.78	30.18
	40.40	31.09	28.65	24.34	24.77	29.45	26.09
pH (H <sub>2</sub> O)	5.73	6.16	6.32	6.55	6.75	6.82	6.32
	5.96	5.91	6.21	6.1	6.27	6.62	6.09
pH (KCl)	4.65	4.66	4.7	4.74	4.86	4.98	4.75
	4.64	4.5	4.79	4.67	4.5	4.88	4.65
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	16.67	17.15	16.78	13.39	12.99	14.18	15.06
	17.13	23.59	17.41	17.27	13.20	15.08	17.19
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.85	0.91	0.61	0.63	0.50	0.56	0.86
	1.96	1.50	1.32	1.06	0.76	0.58	1.11
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	20.51	16.26	11.28	12.21	9.41	8.97	21.08
	129.66	25.38	22.36	22.50	21.79	10.83	12.57
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	35.03	10.02	7.24	8.14	7.57	5.49	28.00
	68.82	29.63	8.81	4.69	6.31	6.92	8.55
Al (g.kg <sup>-1</sup> )	79.04	78.85	116.44	97.56	107.87	102.79	40.81
	85.65	84.29	88.48	87.53	97.63	110.98	92.45
Si (g.kg <sup>-1</sup> )	602.23	530.44	669.89	719.73	553.11	465.19	628.79
	643.08	609.79	665.14	670.98	568.73	574.55	621.34
K <sup>+</sup> (mg.kg <sup>-1</sup> )	6.97	5.60	5.60	5.60	5.60	5.60	4.92
	6.97	5.60	5.60	6.29	5.60	5.60	5.88
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	77.84	51.19	50.31	35.70	31.54	35.70	30.72
	67.85	54.74	49.43	32.37	26.64	30.72	34.03
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	28.15	10.83	38.98	38.98	43.31	25.99	25.99
	28.15	19.49	38.98	21.66	12.99	25.99	58.47
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.16	0.12	0.23	0.23	0.17	0.26	0.08
	0.30	0.20	0.19	0.18	0.23	0.28	0.37
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	15.36	20.16	15.56	13.22	8.41	21.63	21.63
	10.81	30.04	24.03	16.65	25.23	20.43	12.02
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	50.07	42.05	44.06	26.03	34.04	18.02	28.04
	34.04	16.02	44.06	36.05	20.03	22.03	32.04
TOC (%)	2.39	0.92	0.67	0.69	0.72	0.79	0.97
	2.06	1.57	0.97	0.81	0.65	0.59	0.52
Mn (g.kg <sup>-1</sup> )	0.16	0.14	0.12	0.12	0.32	0.45	0.18
	0.11	0.57	0.65	0.54	0.36	0.33	0.52
Fe (g.kg <sup>-1</sup> )	26.80	23.53	30.41	29.13	32.16	30.40	24.76
	24.32	29.83	27.41	26.22	27.12	36.89	27.60

**Table.6: Analytical results for region 4 (Marsh soil, paddy field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	44.53	35.49	28.78	19.27	18.15	27.15	23.06
pH (H <sub>2</sub> O)	42.81	32.90	23.56	24.61	26.20	26.72	17.47
pH (KCl)	5.63	5.63	5.60	5.81	6.07	6.39	6.75
	5.69	5.33	5.75	6.31	6.02	7.08	6.62
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	4.60	4.37	3.92	3.87	3.99	4.62	4.84
	4.46	4.10	3.94	3.96	4.37	4.94	4.91
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	7.48	7.15	6.03	8.03	9.50	14.79	15.02
	12.99	12.47	9.86	11.90	10.29	15.98	7.86
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	2.99	2.50	1.35	0.94	0.82	0.99	0.71
	3.00	3.17	1.28	0.83	0.78	0.59	0.49
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	161.13	126.47	24.59	21.63	17.14	16.95	12.06
	138.04	52.96	22.11	21.30	15.27	15.36	9.57
Al (g.kg <sup>-1</sup> )	90.73	64.60	22.26	8.26	6.16	10.14	6.28
	42.90	62.93	20.41	6.72	7.11	6.65	7.38
Si (g.kg <sup>-1</sup> )	42.35	83.36	88.02	42.43	85.84	107.52	109.43
	83.37	87.12	85.51	87.56	57.38	96.43	107.25
K <sup>+</sup> (mg.kg <sup>-1</sup> )	584.26	638.61	684.42	657.41	710.16	596.03	565.40
	641.24	660.28	693.60	621.37	574.70	566.40	565.56
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	5.60	4.24	3.56	4.24	4.24	5.60	5.60
	4.92	4.24	3.56	4.24	4.24	4.92	6.97
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	45.07	49.43	25.83	25.02	30.72	49.43	47.68
	42.48	45.07	32.37	37.38	38.23	44.20	49.43
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	36.81	28.15	38.98	30.32	41.14	23.82	25.99
	12.99	19.49	43.31	15.16	34.65	19.49	17.32
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	0.19	0.09	0.18	0.18	0.12	0.13	0.14
	0.18	0.18	0.22	0.19	0.06	0.16	0.30
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	6.01	31.24	30.04	12.02	58.88	31.24	18.02
	10.65	10.81	19.22	24.03	6.01	25.61	2.40
TOC (%)	42.05	20.03	20.03	24.03	30.04	38.05	32.04
	44.06	36.05	20.03	26.03	34.04	32.04	52.07
Mn (g.kg <sup>-1</sup> )	2.67	2.51	0.96	0.34	0.38	0.83	0.38
	1.25	2.07	1.57	0.53	0.48	0.31	0.21
Fe (g.kg <sup>-1</sup> )	0.25	0.27	0.20	0.09	0.09	0.11	0.15
	0.21	0.26	0.13	0.07	0.07	0.14	0.10
	26.37	27.26	24.83	14.94	21.24	32.74	34.16
	24.03	24.75	21.66	27.05	34.28	27.42	27.74

**Table.7: Analytical results for region 5 (Marsh soil, forest land)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	28.63	30.86	31.53	25.95	21.86	23.18	23.55
	28.95	29.19	30.08	22.13	22.19	20.12	22.54
pH (H <sub>2</sub> O)	5.24	5.25	5.29	5.29	5.58	5.81	6.07
	5.19	5.15	5.27	5.61	5.53	5.83	6.16
pH (KCl)	4.28	4.28	4.35	4.15	4.27	4.11	4.32
	4.40	4.45	4.40	4.38	4.04	4.20	4.29
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	7.44	10.43	9.53	8.59	8.54	9.33	11.33
	15.93	14.80	14.22	17.59	11.78	14.39	16.29
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.71	1.76	1.61	1.34	0.88	0.68	0.68
	1.68	1.72	1.53	1.07	1.00	0.73	0.68
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	19.77	14.89	22.26	22.21	21.29	11.91	12.39
	14.66	16.36	16.59	15.55	12.02	10.08	12.02
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	9.57	4.56	0.37	3.23	1.66	1.90	2.20
	1.52	3.85	2.65	4.20	1.35	1.30	2.30
Al (g.kg <sup>-1</sup> )	103.93	82.02	85.91	80.39	87.85	116.15	113.33
	82.28	79.85	79.57	11.67	78.68	109.60	86.81
Si (g.kg <sup>-1</sup> )	720.27	633.31	598.01	504.81	744.90	591.06	582.46
	659.41	525.12	405.08	632.40	655.18	617.34	756.68
K <sup>+</sup> (mg.kg <sup>-1</sup> )	11.51	6.30	5.08	7.34	5.62	4.94	5.28
	8.71	12.25	5.62	5.28	4.94	4.94	6.99
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	43.64	18.07	16.11	14.96	24.98	30.14	25.77
	13.08	14.58	15.72	19.54	22.64	22.25	29.35
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	64.97	25.99	20.57	15.16	9.74	20.57	18.41
	16.24	18.41	4.33	4.33	11.91	2.17	23.82
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.22	0.19	0.31	0.49	0.36	0.27	0.22
	0.28	0.27	0.22	0.19	0.16	0.21	0.15
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	16.01	27.64	24.63	37.85	43.86	4.21	16.82
	33.64	47.46	42.05	73.30	34.24	34.85	33.64
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	35.05	51.07	42.05	27.04	20.03	40.05	17.02
	49.06	61.08	60.08	48.06	40.05	56.07	39.05
TOC (%)	2.85	2.39	2.42	1.55	0.70	0.56	0.51
	3.32	3.74	2.58	1.34	0.80	0.70	0.45
Mn (g.kg <sup>-1</sup> )	0.19	0.21	0.16	0.14	0.22	0.10	0.09
	0.25	0.17	0.29	0.21	0.13	0.17	0.11
Fe (g.kg <sup>-1</sup> )	25.79	26.72	24.40	24.30	30.10	35.05	34.57
	29.58	26.04	33.52	25.39	29.33	39.86	32.25

**Table.8: Analytical results for region 6 (Marsh soil, forest land)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	43.63	30.57	23.97	23.95	27.69	28.33	27.72
	35.60	33.73	24.98	25.07	24.34	27.83	27.36
pH (H <sub>2</sub> O)	5.17	5.18	5.43	5.65	5.79	5.92	5.98
	5.34	5.16	5.49	5.60	5.64	5.92	6.08
pH (KCl)	4.46	4.23	4.22	4.24	4.19	4.14	4.25
	4.60	4.28	4.33	4.29	4.15	4.21	4.30
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	15.51	16.23	31.96	15.32	18.80	21.09	14.04
	16.70	18.91	23.52	24.43	19.00	12.56	19.15
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.81	1.48	0.60	0.65	0.77	0.30	0.52
	1.11	1.12	0.60	0.35	0.48	0.49	0.31
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	48.49	38.14	32.21	29.64	28.42	32.26	22.36
	21.47	23.74	11.39	13.09	12.85	10.46	11.03
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	29.77	17.51	5.07	2.80	4.79	5.62	8.02
	6.87	5.16	1.68	3.05	2.82	3.68	2.04
Al (g.kg <sup>-1</sup> )	84.28	86.48	89.32	94.46	105.05	121.68	114.29
	81.76	88.34	91.63	89.95	107.65	114.61	110.42
Si (g.kg <sup>-1</sup> )	547.93	655.78	667.79	644.55	621.65	539.35	615.49
	605.28	655.72	631.52	558.45	596.08	612.98	644.74
K <sup>+</sup> (mg.kg <sup>-1</sup> )	9.93	2.91	2.04	2.04	2.04	2.04	1.16
	8.25	16.94	6.42	3.79	3.79	2.04	3.79
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	18.18	19.39	18.78	22.46	21.84	26.27	19.99
	19.16	33.58	21.84	20.61	28.22	16.99	26.27
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	25.21	10.74	8.87	11.67	9.80	8.40	16.34
	25.21	9.34	8.87	13.07	15.41	4.67	11.20
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.11	0.11	0.10	0.12	0.13	0.12	0.02
	0.07	0.30	0.12	0.18	0.11	0.08	0.07
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	66.09	30.04	13.22	35.45	33.04	19.22	7.81
	21.63	37.85	24.63	36.05	45.66	31.84	7.21
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	30.04	22.03	30.04	24.03	18.02	22.03	26.03
	30.04	31.04	29.04	26.03	9.01	15.02	42.05
TOC (%)	3.12	0.26	0.69	0.61	0.63	0.54	0.58
	3.03	2.33	1.11	0.72	0.62	0.49	0.27
Mn (g.kg <sup>-1</sup> )	1.06	1.05	1.38	0.57	0.40	0.42	0.45
	1.08	1.10	1.76	1.07	0.74	0.41	0.38
Fe (g.kg <sup>-1</sup> )	26.18	26.76	31.19	28.40	32.04	38.47	34.84
	27.51	27.86	34.93	33.02	33.02	36.27	35.40

**Table.9: Analytical results for region 7 (Marsh soil, upland field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	31.36	36.42	34.34	28.24	27.37	26.54	27.29
	32.74	29.95	31.93	27.54	28.65	27.24	25.35
pH (H <sub>2</sub> O)	5.28	5.24	5.40	5.06	5.31	5.28	6.05
	5.32	5.47	5.53	5.58	5.75	6.54	6.65
pH (KCl)	4.03	4.26	4.85	4.13	3.81	4.52	4.12
	4.67	4.04	4.08	4.20	4.25	4.98	5.13
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	4.89	3.54	5.42	4.43	10.40	14.67	11.31
	7.89	7.29	6.22	3.47	5.06	15.78	16.50
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.19	1.06	1.78	1.24	1.15	0.68	0.64
	1.72	1.06	1.12	0.93	0.95	0.62	0.60
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	26.57	29.90	30.20	37.18	38.03	20.92	17.30
	99.23	81.48	69.84	76.82	98.37	52.66	52.23
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	3.53	10.98	11.73	8.47	13.31	6.64	3.92
	18.15	6.27	3.89	9.30	10.35	8.26	5.32
Al (g.kg <sup>-1</sup> )	107.44	107.42	109.03	101.80	110.45	88.72	100.62
	112.31	143.17	90.30	126.58	108.91	124.33	86.53
Si (g.kg <sup>-1</sup> )	614.28	584.68	546.29	626.82	620.02	505.78	514.64
	597.00	784.02	518.52	629.56	561.94	689.12	443.04
K <sup>+</sup> (mg.kg <sup>-1</sup> )	14.68	12.55	5.60	16.11	10.44	13.97	13.26
	24.88	11.85	9.74	10.44	9.05	19.72	16.11
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	22.62	28.26	36.54	25.83	17.88	19.45	19.45
	26.64	16.32	14.77	15.54	14.77	16.32	30.72
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	32.48	47.64	93.12	49.81	30.32	30.32	21.66
	34.65	32.48	32.48	30.32	28.15	34.65	116.94
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.26	0.18	0.22	0.42	0.12	0.20	0.26
	0.19	0.18	0.18	0.24	0.11	0.17	0.21
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	22.83	52.87	66.09	74.50	68.49	61.28	40.85
	128.57	38.45	55.27	32.44	103.33	57.67	84.11
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	50.07	112.15	170.22	50.07	28.04	44.06	20.03
	66.09	32.04	20.03	42.05	34.04	36.05	80.10
TOC (%)	0.82	1.63	6.11	1.33	0.73	1.05	0.41
	5.12	0.72	0.72	0.77	0.88	0.24	0.37
Mn (g.kg <sup>-1</sup> )	0.17	0.18	0.27	0.18	0.04	0.03	0.04
	0.04	0.06	0.04	0.05	0.04	0.05	0.02
Fe (g.kg <sup>-1</sup> )	22.80	22.64	20.42	19.69	26.12	17.27	19.90
	31.48	42.00	21.23	36.39	29.46	26.93	18.46

**Table.10: Analytical results for region 8 (Marsh soil, upland field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	14.40	25.19	18.13	15.88	17.15	21.86	16.52
	19.09	25.81	22.52	20.63	20.43	19.95	22.90
pH (H <sub>2</sub> O)	5.14	5.35	5.70	6.46	6.77	6.83	6.91
	5.15	5.29	5.70	5.90	6.58	6.74	6.90
pH (KCl)	4.30	4.44	4.38	4.87	4.89	4.86	5.02
	4.35	4.43	4.57	4.80	5.01	4.93	4.97
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	11.03	10.77	9.71	9.78	10.58	13.09	4.69
	16.10	15.75	15.78	12.04	11.49	13.83	14.83
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.83	1.81	1.26	0.69	0.57	0.51	0.43
	1.74	1.77	1.43	1.19	0.81	0.56	0.61
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	18.69	16.20	20.08	13.32	14.26	11.78	10.53
	22.64	22.29	18.56	15.15	13.64	10.80	11.01
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	10.69	4.42	2.60	1.32	3.52	4.11	5.86
	12.71	6.49	2.31	3.10	5.01	5.17	1.30
Al (g.kg <sup>-1</sup> )	100.84	83.36	85.43	88.18	104.36	110.22	107.62
	81.81	82.68	85.87	129.07	83.47	107.86	71.25
Si (g.kg <sup>-1</sup> )	610.83	625.54	371.41	581.59	533.80	531.47	601.39
	530.55	607.19	635.70	662.33	698.68	543.50	546.74
K <sup>+</sup> (mg.kg <sup>-1</sup> )	9.41	6.30	4.94	6.65	5.96	4.94	5.28
	8.36	7.33	5.28	3.59	4.60	3.59	10.97
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	39.91	21.50	16.49	14.96	22.25	26.97	25.77
	13.84	13.46	14.21	56.03	44.06	36.63	28.15
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	47.64	42.23	35.73	20.57	21.66	31.40	25.99
	55.22	37.90	43.31	96.36	18.41	24.90	20.57
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.22	0.27	0.24	0.20	0.41	0.35	0.28
	0.01	0.23	0.19	0.17	0.25	0.04	0.13
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	30.04	22.83	13.22	8.41	9.01	20.86	15.89
	24.63	67.89	13.82	15.60	22.23	28.24	25.23
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	60.08	45.06	50.07	36.05	45.06	37.05	152.20
	74.10	52.07	50.07	89.12	36.05	35.05	31.04
TOC (%)	2.35	0.37	1.07	0.44	0.48	0.36	0.18
	2.63	2.69	1.60	1.44	0.78	0.47	0.29
Mn (g.kg <sup>-1</sup> )	0.17	0.19	0.12	0.12	0.11	0.08	0.05
	0.17	0.19	0.15	0.12	0.13	0.10	0.10
Fe (g.kg <sup>-1</sup> )	30.37	28.09	26.37	27.86	31.04	34.26	22.67
	25.30	25.59	29.46	24.26	26.88	36.54	36.88

**Table.11: Analytical results for region 9 (Albic soil, wetland)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	62.93	32.94	23.58	23.60	26.46	25.83	22.87
pH (H <sub>2</sub> O)	44.08	25.06	30.36	30.26	29.32	20.04	26.52
pH (KCl)	5.1	5.12	5.23	5.42	5.73	5.75	5.79
	5.07	5.32	5.42	5.27	5.65	5.93	6.12
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	3.86	3.62	3.49	3.51	3.53	3.61	3.78
	3.73	3.5	3.48	3.5	3.5	3.7	3.93
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	10.42	11.10	8.56	8.32	8.69	11.64	8.78
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	8.06	7.63	7.53	7.59	6.29	7.07	5.85
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	3.78	1.57	0.79	0.95	0.65	0.60	0.62
	1.98	0.83	0.74	0.77	0.78	0.52	0.39
Al (g.kg <sup>-1</sup> )	222.60	206.86	101.26	102.67	77.42	60.60	57.24
	46.40	24.31	19.20	16.35	17.52	15.96	12.06
Si (g.kg <sup>-1</sup> )	92.71	3.63	6.54	5.51	5.10	3.56	3.65
	6.49	4.82	4.48	6.47	6.24	2.16	4.10
K <sup>+</sup> (mg.kg <sup>-1</sup> )	75.57	82.33	82.66	120.72	98.08	111.55	104.01
	82.30	78.48	75.98	82.72	94.30	107.58	88.97
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	647.71	721.21	720.91	656.37	622.89	597.86	625.63
	616.22	684.25	614.98	664.44	609.46	519.45	596.65
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	17.82	2.04	1.16	1.16	2.04	2.91	2.91
	10.80	2.04	1.16	1.16	2.04	2.04	2.91
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	26.27	21.22	21.22	27.57	30.87	45.71	62.91
	25.63	24.99	24.99	32.22	28.22	38.45	65.39
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	26.68	19.61	7.94	11.67	3.73	22.41	28.48
	25.68	11.67	12.14	14.47	5.14	12.60	28.48
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	0.12	0.09	0.15	0.06	0.06	0.19	0.13
	0.06	0.05	0.08	0.10	0.13	0.07	0.10
TOC (%)	5.41	19.22	16.82	15.62	21.63	25.83	10.21
	12.83	15.02	20.64	25.83	20.25	16.22	15.23
Mn (g.kg <sup>-1</sup> )	31.04	19.02	21.03	15.02	22.03	18.02	24.03
	19.02	15.02	20.03	16.02	24.03	17.02	23.03
Fe (g.kg <sup>-1</sup> )	4.17	1.66	0.58	0.68	0.57	0.64	0.75
	2.26	0.59	0.53	0.69	0.64	0.54	0.53
	0.24	0.19	0.19	0.04	0.03	0.03	0.03
	0.14	0.04	0.03	0.03	0.03	0.03	0.03
	21.76	23.42	21.21	34.26	30.67	33.89	31.79
	22.46	20.47	21.99	24.64	31.39	33.88	24.56

**Table.12: Analytical results for region 10 (Albic soil, wetland)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	54.01	24.36	26.06	27.19	29.34	25.78	25.14
	27.41	26.15	22.59	26.97	40.90	24.92	21.42
pH (H <sub>2</sub> O)	5.31	5.65	5.44	5.65	5.41	6.03	6.26
	5.41	5.43	5.33	5.37	5.53	6.09	6.7
pH (KCl)	4.45	4.31	4.09	3.86	3.68	4.25	4.64
	4.33	4.17	3.88	3.72	3.74	4.32	4.9
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	4.20	2.14	3.04	5.82	23.95	8.58	15.02
	3.16	2.69	7.88	22.41	15.22	11.30	12.73
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	3.06	0.94	1.20	1.33	1.04	0.50	0.50
	1.06	1.20	1.27	1.52	1.20	0.58	0.50
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	243.02	88.98	134.88	155.35	113.55	55.83	61.79
	23.60	38.43	26.65	35.97	33.05	15.29	11.42
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	5.31	14.11	15.58	13.56	16.38	9.71	4.33
	2.50	10.45	12.58	10.52	7.16	10.82	10.37
Al (g.kg <sup>-1</sup> )	67.58	58.39	97.55	86.52	99.30	100.54	90.20
	91.28	93.60	105.48	103.42	124.23	114.26	105.96
Si (g.kg <sup>-1</sup> )	528.43	688.91	611.42	706.24	653.21	632.26	600.12
	624.67	607.09	578.85	580.49	548.07	578.09	604.79
K <sup>+</sup> (mg.kg <sup>-1</sup> )	14.25	9.05	8.17	8.17	4.67	4.67	7.30
	7.30	8.17	7.30	5.54	4.67	6.42	6.42
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	32.90	18.18	16.40	18.78	12.36	11.23	9.03
	15.81	17.58	22.46	18.18	15.81	15.22	8.49
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	17.78	26.14	23.34	19.14	17.27	14.94	12.14
	17.74	16.81	27.08	18.21	23.34	17.27	3.27
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.14	0.09	0.09	0.18	0.18	0.17	0.16
	0.08	0.12	0.08	0.17	0.16	0.12	0.20
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	15.65	31.24	21.63	10.81	16.22	12.62	18.62
	12.62	15.02	22.56	13.22	21.03	31.84	19.83
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	12.56	22.56	22.03	24.03	24.03	20.03	18.02
	18.02	24.03	46.06	27.04	18.02	23.03	28.04
TOC (%)	10.76	1.17	1.11	0.87	0.76	0.44	0.50
	2.43	1.43	0.83	0.91	0.76	0.40	0.28
Mn (g.kg <sup>-1</sup> )	0.06	0.03	0.02	0.03	0.16	0.25	0.28
	0.12	0.14	0.15	0.15	0.15	0.17	0.23
Fe (g.kg <sup>-1</sup> )	14.29	12.85	12.22	20.65	30.56	31.56	25.41
	11.93	12.17	17.77	29.75	34.62	32.84	29.75

**Table.13: Analytical results for region 11 (Albic soil, paddy field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	48.69	49.62	48.15	34.15	24.17	33.26	27.69
	44.80	47.10	25.54	25.90	27.03	25.06	25.95
pH (H <sub>2</sub> O)	5.59	5.42	5.37	5.62	5.56	5.83	5.18
	5.16	5.15	5.4	5.32	5.55	5.99	5.99
pH (KCl)	4.61	4.45	4.18	4.42	4	4.2	4.4
	4.22	4.11	4.02	3.96	3.99	4.15	4.31
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	14.06	14.39	9.93	12.89	7.51	9.95	4.84
	15.55	18.59	9.88	15.46	1.10	10.68	5.39
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	2.59	2.36	1.57	1.97	0.66	0.76	0.59
	2.39	0.94	0.70	0.78	0.71	0.60	0.73
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	204.51	147.49	33.88	107.28	16.46	14.07	11.42
	33.66	30.86	14.41	10.96	11.42	12.31	10.39
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	183.60	65.69	84.54	7.61	8.31	5.52	5.26
	192.20	65.58	6.71	6.89	3.96	6.00	5.22
Al (g.kg <sup>-1</sup> )	82.25	86.72	79.21	88.03	101.37	23.64	112.73
	81.57	83.89	86.06	104.94	105.37	109.54	110.61
Si (g.kg <sup>-1</sup> )	625.53	588.76	623.88	601.58	480.61	555.26	595.61
	519.25	640.42	610.57	604.20	696.98	598.04	585.72
K <sup>+</sup> (mg.kg <sup>-1</sup> )	9.46	8.80	5.54	6.83	4.90	4.90	6.19
	6.83	6.19	4.90	4.90	4.90	5.54	4.90
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	28.88	26.92	26.92	25.63	26.27	31.55	30.87
	28.22	19.99	19.39	24.99	28.22	27.57	26.27
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	31.28	27.54	23.34	17.27	18.21	11.20	20.07
	18.67	7.00	18.21	23.81	32.21	14.00	5.14
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.14	0.21	0.14	0.17	0.15	0.23	0.25
	0.23	0.21	0.31	0.17	0.43	0.18	0.19
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	34.24	55.27	61.28	36.65	73.30	24.03	42.66
	45.66	88.92	69.69	27.64	47.46	56.47	68.49
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	30.04	24.03	21.03	20.03	12.02	21.03	15.02
	21.03	23.03	17.02	29.04	23.03	20.03	27.04
TOC (%)	3.29	3.31	2.38	2.51	0.57	1.44	0.52
	3.97	2.32	0.50	0.70	0.64	0.47	0.42
Mn (g.kg <sup>-1</sup> )	1.21	1.49	0.95	0.94	0.29	0.18	0.55
	1.25	1.47	1.02	0.53	0.46	0.42	0.48
Fe (g.kg <sup>-1</sup> )	27.77	31.37	25.43	25.63	26.56	7.87	34.25
	26.52	30.90	30.12	30.54	32.80	35.58	33.98

**Table.14: Analytical results for region 12 (Albic soil, paddy field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	47.72	33.18	26.70	39.42	27.11	24.97	31.19
	48.09	25.92	24.65	27.90	24.74	18.42	29.24
pH (H <sub>2</sub> O)	5.8	5.58	5.75	5.76	5.8	5.81	6.04
	5.71	5.24	5.52	5.55	5.89	5.77	5.52
pH (KCl)	4.46	3.77	3.66	3.64	3.63	3.82	3.92
	4.59	3.91	3.82	3.79	3.71	3.9	4.00
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	15.43	17.15	12.07	13.45	7.27	9.14	9.26
	10.93	9.09	9.05	7.69	5.38	5.96	8.15
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	3.22	1.80	1.25	1.21	1.00	1.17	0.96
	3.28	1.12	0.80	0.90	0.86	0.90	0.79
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	197.76	56.05	28.33	20.81	19.63	14.33	14.15
	177.59	20.21	15.40	18.67	17.67	121.74	14.61
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	28.24	66.38	10.53	6.60	6.36	4.60	4.90
	66.51	41.94	1.99	1.34	1.32	4.56	3.20
Al (g.kg <sup>-1</sup> )	88.34	83.66	79.17	94.73	112.59	113.86	105.04
	78.14	81.48	89.45	97.65	107.11	108.56	106.63
Si (g.kg <sup>-1</sup> )	574.69	605.94	742.64	626.57	764.52	655.64	658.79
	670.93	738.92	774.08	595.97	569.20	733.96	806.12
K <sup>+</sup> (mg.kg <sup>-1</sup> )	6.29	4.92	5.60	8.36	4.92	7.66	10.44
	7.66	6.29	6.29	8.36	5.60	7.66	5.60
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	52.47	48.77	55.24	69.13	35.81	65.43	132.06
	54.32	39.51	6.19	50.62	48.77	96.89	65.43
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	57.42	45.28	33.14	17.74	24.27	19.14	29.41
	5.60	13.07	11.40	22.41	16.34	16.81	24.74
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.10	0.21	0.28	0.25	0.09	0.07	0.29
	0.23	0.31	0.49	0.32	0.24	0.19	0.20
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	18.02	40.85	61.88	10.81	25.23	1.80	60.68
	54.67	25.23	25.23	10.21	20.43	12.62	20.43
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	35.05	19.02	16.02	52.07	32.04	46.06	25.03
	25.03	28.04	30.04	26.03	21.03	25.03	35.05
TOC (%)	2.84	1.28	0.66	0.80	0.59	0.73	0.60
	2.64	0.90	0.41	0.41	0.41	0.99	0.38
Mn (g.kg <sup>-1</sup> )	0.58	0.46	0.75	0.27	0.17	0.22	0.25
	1.17	1.06	0.33	0.29	0.19	0.33	0.22
Fe (g.kg <sup>-1</sup> )	20.80	22.28	21.67	28.13	33.25	30.89	31.69
	24.92	22.17	20.64	22.25	25.41	30.20	28.41

**Table.15: Analytical results for region 13 (Albic soil, forest land)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	46.70	29.15	19.10	20.47	20.76	19.84	13.08
	29.60	24.55	19.36	22.54	21.44	21.10	20.38
pH (H <sub>2</sub> O)	5.00	5.10	5.43	5.38	5.43	5.64	5.83
	5.22	5.21	5.38	5.32	5.44	5.71	5.88
pH (KCl)	3.91	3.71	3.74	3.6	3.58	3.55	3.75
	4.35	3.85	3.83	3.83	3.78	3.84	3.81
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	13.32	13.13	11.10	20.92	23.05	27.17	26.97
	16.35	16.58	17.35	23.67	13.74	24.41	27.82
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.69	1.03	0.62	0.73	0.81	0.71	0.64
	1.43	0.94	0.64	0.58	0.53	0.66	0.71
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	24.79	22.86	16.15	17.00	13.85	14.60	11.20
	14.24	18.69	13.29	14.35	13.87	12.66	13.00
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	31.15	18.35	6.46	3.66	2.93	6.20	4.75
	30.22	8.69	7.80	6.91	7.84	6.30	3.98
Al (g.kg <sup>-1</sup> )	78.26	76.52	84.00	105.32	103.67	114.19	105.87
	84.17	82.67	92.82	92.46	102.11	98.95	108.20
Si (g.kg <sup>-1</sup> )	603.90	774.81	656.42	666.35	641.59	627.59	614.05
	571.27	687.56	765.62	684.28	693.41	741.53	577.80
K <sup>+</sup> (mg.kg <sup>-1</sup> )	7.67	3.93	6.64	6.30	6.30	7.67	5.62
	15.19	5.54	2.04	2.04	2.04	2.04	2.04
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	15.72	13.84	45.75	34.58	41.26	52.61	51.71
	16.99	16.99	16.40	18.18	20.61	27.57	28.22
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	18.41	20.57	22.74	16.24	23.82	21.66	21.66
	16.34	7.47	16.34	10.27	7.00	4.20	7.00
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.22	0.20	0.32	0.29	0.25	0.18	0.13
	0.24	0.12	0.12	0.13	0.34	0.26	0.15
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	22.83	29.44	51.07	54.67	81.11	55.87	59.48
	7.81	13.82	8.41	42.66	27.64	22.83	9.61
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	39.05	31.04	25.03	29.04	35.05	27.04	31.04
	28.04	22.03	31.04	17.02	16.02	16.02	28.04
TOC (%)	3.96	1.11	0.53	0.41	0.42	0.34	0.27
	5.49	1.34	0.46	0.49	0.37	0.30	0.37
Mn (g.kg <sup>-1</sup> )	0.33	0.42	0.45	0.56	0.15	0.20	0.22
	0.48	0.40	0.27	0.26	0.18	0.33	0.08
Fe (g.kg <sup>-1</sup> )	20.11	25.13	30.26	155.07	39.95	38.17	38.03
	22.20	23.89	24.79	29.52	28.25	35.74	37.56

**Table.16: Analytical results for region 14 (Albic soil, forest land)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	26.51	25.91	21.71	20.97	27.34	22.86	22.18
	22.82	24.25	26.22	25.11	27.29	25.11	21.99
pH (H <sub>2</sub> O)	5.27	5.53	5.72	5.67	5.72	6.00	6.28
	5.30	5.51	5.61	5.66	5.73	5.93	6.27
pH (KCl)	4.29	4.27	4.17	3.96	3.89	4.04	4.24
	4.13	3.93	3.73	3.72	3.76	3.89	4.25
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	20.34	20.64	22.59	16.93	15.50	15.97	22.27
	15.88	23.22	9.83	18.63	21.60	20.79	19.95
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.21	0.83	0.62	0.68	0.71	0.71	0.54
	0.98	0.63	0.57	0.72	0.60	0.56	0.56
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	12.91	10.95	9.78	11.99	13.64	12.20	9.14
	15.73	14.20	13.71	16.40	18.08	11.18	15.02
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	6.32	5.11	2.94	0.00	1.25	0.00	1.45
	6.78	2.96	1.83	0.00	0.75	4.45	2.87
Al (g.kg <sup>-1</sup> )	95.07	82.64	79.33	93.77	107.59	112.44	109.65
	76.85	84.78	105.93	112.40	116.26	115.19	108.02
Si (g.kg <sup>-1</sup> )	727.42	740.66	757.89	369.93	559.52	602.77	787.57
	560.82	673.23	652.36	599.46	659.51	625.64	617.39
K <sup>+</sup> (mg.kg <sup>-1</sup> )	14.68	6.29	4.92	4.92	5.60	6.29	6.29
	17.55	4.92	5.60	7.66	6.29	5.60	6.29
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	20.24	25.02	17.88	29.90	35.70	36.54	34.87
	32.37	17.10	28.26	31.54	54.74	41.63	48.55
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	56.30	28.15	30.32	38.98	57.89	41.08	11.20
	30.32	32.48	21.66	43.31	62.55	44.82	36.41
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.25	0.14	0.17	0.13	0.13	0.22	0.15
	0.18	0.05	0.10	0.11	0.10	0.24	0.16
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	69.69	79.30	18.02	23.56	16.52	24.03	43.26
	28.84	92.52	57.67	56.20	43.05	50.47	28.84
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	56.07	42.05	38.05	68.09	36.05	30.04	32.04
	50.07	38.05	40.05	22.03	46.06	36.05	48.06
TOC (%)	2.27	1.08	0.56	0.62	0.56	0.60	0.41
	1.87	0.81	0.48	0.63	0.46	0.47	0.51
Mn (g.kg <sup>-1</sup> )	0.40	0.43	0.49	0.19	0.10	0.12	0.23
	0.24	0.29	0.09	0.12	0.42	0.61	0.58
Fe (g.kg <sup>-1</sup> )	30.51	28.54	34.56	30.36	33.12	34.57	36.82
	23.35	26.73	30.02	32.65	36.24	35.62	34.85

**Table.17: Analytical results for region 15 (Albic soil, upland field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	30.71	22.72	26.49	27.73	35.03	23.20	31.49
	32.60	32.17	27.00	27.84	32.14	27.61	25.33
pH (H <sub>2</sub> O)	4.87	4.97	5.33	5.68	6.2	6.61	6.76
	4.79	5.01	5.28	5.43	6.19	6.75	6.77
pH (KCl)	4.03	4.05	4.00	4.18	4.55	4.88	4.87
	4.12	3.96	3.96	4.11	4.67	5.05	4.95
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	8.43	14.54	21.38	17.57	14.18	14.00	13.60
	13.27	28.20	13.22	8.53	16.17	12.22	9.95
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	2.99	2.96	1.57	1.19	0.70	0.55	0.62
	3.55	1.43	1.45	1.51	0.82	0.57	0.56
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	83.16	22.26	24.85	31.72	100.75	21.88	59.73
	96.63	56.35	60.25	55.74	19.85	14.62	15.86
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	17.62	11.68	7.32	10.92	9.54	4.91	14.17
	5.12	22.25	4.56	7.60	5.84	3.73	6.28
Al (g.kg <sup>-1</sup> )	88.44	90.31	100.19	92.70	107.28	108.37	105.71
	77.46	72.91	79.97	81.99	92.16	109.80	0.00
Si (g.kg <sup>-1</sup> )	642.65	583.36	629.02	829.45	632.95	618.54	652.03
	622.46	617.48	757.67	625.42	541.83	555.25	0.00
K <sup>+</sup> (mg.kg <sup>-1</sup> )	10.09	10.44	6.29	6.29	6.29	8.70	8.01
	11.51	7.32	6.29	6.97	9.05	9.74	11.15
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	50.90	37.66	43.68	34.42	33.03	38.59	39.51
	45.95	31.97	33.24	28.26	26.64	28.67	29.90
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	39.68	28.48	42.95	29.88	30.34	31.28	31.28
	31.74	34.55	31.28	24.74	32.68	30.81	41.08
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.06	0.19	0.12	0.19	0.19	0.11	0.18
	0.37	0.26	0.28	0.16	0.32	0.31	0.13
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	7.81	48.66	23.43	36.65	30.23	31.24	11.23
	42.05	25.23	17.42	30.04	48.06	25.23	12.62
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	176.23	79.10	51.07	32.04	118.15	35.05	122.16
	120.16	38.05	49.06	49.06	45.06	40.05	45.06
TOC (%)	3.58	2.74	0.92	0.86	0.59	0.42	0.43
	4.15	0.93	0.88	1.08	0.66	0.39	0.32
Mn (g.kg <sup>-1</sup> )	0.21	0.18	0.18	0.21	0.20	0.29	0.60
	0.23	0.25	0.26	0.52	0.41	0.28	0.35
Fe (g.kg <sup>-1</sup> )	23.83	29.60	36.88	35.53	33.99	32.19	31.95
	25.11	33.85	26.00	20.84	32.34	30.64	28.15

**Table.18: Analytical results for region 16 (Albic soil, upland field)**

Analytical items	Soil layer						
	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40-60 cm	60-90 cm	90-120 cm
Moisture content (%)	21.88	24.41	25.85	24.77	20.79	25.05	23.82
	22.82	30.93	23.92	24.87	23.56	27.92	26.11
pH (H <sub>2</sub> O)	5.18	5.22	5.19	5.1	5.56	6.04	6.2
	5.1	4.27	5.06	5.19	5.36	5.93	6.04
pH (KCl)	4.4	4.45	3.98	4.1	3.91	4.1	4.18
	4.38	4.29	4.06	3.95	3.86	4.06	4.22
Free iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) (g.kg <sup>-1</sup> )	4.95	4.52	4.78	2.40	3.63	7.49	4.88
	10.94	3.37	5.65	8.34	6.97	3.13	1.56
Ferric chelate (Fe) (g.kg <sup>-1</sup> )	1.45	1.42	1.88	2.19	0.74	0.34	0.37
	1.38	1.58	1.66	1.03	0.55	0.42	0.41
Fe <sup>2+</sup> (mg.kg <sup>-1</sup> )	20.18	20.50	25.42	30.81	23.06	13.10	11.30
	17.15	17.76	37.62	30.81	27.16	15.22	11.19
Mn <sup>2+</sup> (mg.kg <sup>-1</sup> )	11.61	5.01	2.75	1.61	1.99	5.00	3.19
	13.13	13.38	5.75	6.00	5.22	5.00	2.42
Al (g.kg <sup>-1</sup> )	77.67	79.84	74.80	88.25	102.37	122.11	109.77
	75.41	84.90	84.65	76.91	95.45	97.10	114.59
Si (g.kg <sup>-1</sup> )	710.54	981.85	1105.75	993.84	763.79	592.41	588.00
	627.48	576.18	625.41	718.53	647.93	504.80	298.99
K <sup>+</sup> (mg.kg <sup>-1</sup> )	8.80	8.80	5.54	5.54	6.19	5.54	6.83
	8.14	8.80	5.54	5.54	5.54	5.54	6.19
Na <sup>+</sup> (mg.kg <sup>-1</sup> )	28.22	26.92	23.72	23.72	25.63	30.87	30.87
	28.22	28.22	22.46	23.72	26.92	32.22	37.75
Cl <sup>-</sup> (mg.kg <sup>-1</sup> )	23.34	21.94	11.20	30.34	20.54	18.21	17.27
	255.82	26.61	33.14	18.67	27.08	19.61	22.41
SO <sub>4</sub> <sup>2-</sup> (g.kg <sup>-1</sup> )	0.07	0.22	0.28	0.14	0.24	0.14	0.08
	0.09	0.18	0.22	0.15	0.22	0.18	0.15
Mg <sup>2+</sup> (mg.kg <sup>-1</sup> )	26.43	68.49	53.47	60.68	25.23	13.62	8.41
	13.22	13.82	9.01	14.42	12.62	17.42	16.82
Ca <sup>2+</sup> (mg.kg <sup>-1</sup> )	45.06	32.04	22.03	16.02	18.02	42.05	16.02
	23.03	44.06	24.03	27.04	21.03	13.02	24.03
TOC (%)	2.95	2.73	1.67	1.89	3.26	0.43	0.43
	2.93	3.47	1.49	0.83	0.49	0.53	0.51
Mn (g.kg <sup>-1</sup> )	1.16	1.50	0.59	0.82	0.75	0.49	0.23
	1.75	1.14	0.33	0.35	0.33	0.29	0.35
Fe (g.kg <sup>-1</sup> )	24.77	23.72	21.22	21.09	26.84	34.81	35.62
	33.46	22.55	21.81	20.68	24.87	35.28	36.28