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## **Physical and Chemical Properties of Mangrove Forest Soils**

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# ဒီရေတော သစ်တောမြေများ၏ ရူပ နှင့် ဓါတုဂုဏ်သတ္တိများ

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## စာတမ်းအကျဉ်းချုပ်

မြန်မာနိုင်ငံတွင် ဒီရေတောသစ်တောများ ပေါက်ရောက်သည့် ရခိုင်ကမ်းမြောင်းဒေသ၊ မြစ်ဝကျွန်းပေါ်ဒေသနှင့် တနင်္သာရီကမ်းမြောင်းဒေသများရှိသည့်အနက်၊ ပထမအဆင့်အနေဖြင့် ဤစာတမ်းတွင် ဧရာဝတီတိုင်း ဒီရေတော သစ်တောများ ပေါက်ရောက်သည့် ဘိုကလေးမြို့နယ် မိန်းမလှကျွန်း သစ်တောကြိုးဝိုင်း၊ ကဒုံကန် သစ်တော ကြိုးဝိုင်း၊ ပုသိမ်အနောက်မြို့နယ် ချောင်းသာကမ်း ဒီရေတောတို့မှ မြေနမူနာများ၏ ရူပဂုဏ်သတ္တိနှင့် ဓါတုဂုဏ်သတ္တိများကို ရှာဖွေ၍ သစ်တောစိုက်ခင်းများ ပြန်လည် တည်ထောင်ရာတွင် အထောက်အကူ ပြုနိုင်ရန်အတွက် လေ့လာ တင်ပြထားပါသည်။ ဧရာဝတီတိုင်း ဒီရေတောဒေသများမှ မြေနမူနာများ ရူပနှင့်ဓါတုဂုဏ်သတ္တိများကို လေ့လာရာတွင် နိုက်ထရိုဂျင်၊ ပိုတက်စီယမ်၊ ကယ်လစီယမ်၊ ဆိုဒီယမ်နှင့် ဖော့စဖရပ်အစရှိသည့် အာဟာရဓါတ်များ ကြွယ်ဝမှုရှိပြီး ပျော်ဝင်နိုင်သော ဆားဓါတ်ပါဝင်မှု အခြေအနေမှာလည်း မြင့်သည်ကို တွေ့ရှိရပါသည်။ မြေအချဉ် အင်္ဂါဓါတ်မှာ မျှတသော အခြေအနေနှင့် အချဉ်ဓါတ်အနည်းငယ် ကဲသော အခြေအနေ တွေ့ရှိရပြီး မြေအမျိုးအစားမှာ နုန်းဆန်သော မြေစေးနှင့် မြေစေးများ ဖြစ်သည်ကိုတွေ့ရှိပါသည်။

## **Mangrove forest Soils**

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### **Abstract**

The Mangrove forest soils are found in Delta Area of Ayeyarwady Divisions, Rakhine and Tanintharyi Coastal Areas of Myanmar. In this paper Bogalay Township and Chaungtha Mangrove forest soils of Ayeyarwady Division are described to attribute for the establishment of new plantations. The Mangrove soils of Ayeyarwady Division have rich soil nutrients in Nitrogen, Potassium, Calcium, Magnesium and Sodium. The soils in this area are slightly acid or neutral and mostly clayey or slit loamy soils.

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## 1. Introduction

The salty muds tropical Mangrove forest are found in Delta areas of Yangon and Ayeyarwady Divisions, Rakhine and Tenasserim Coastal areas. Yangon and Ayeyarwady Divisions receive less than 2500 mm/a of precipitation while the coastal areas receive 3000-6000 mm/a precipitations.

The major forest products of these areas are timber, post, poles, firewood, charcoal, bamboo, cane. The minor forest products are daminwe, thin, thabaw, dani, te, honey and barks. Not only the fuelwoods but also other products from area are in great demand for local use and foreign exports. Due to over exploitation some of the Mangrove forests in this areas are degraded. Therefore natural regeneration alone may not be sufficient to fulfill the heavy domestic and export demands, that artificial regeneration with sound management may be required.

For intensive and successful for management practices, it is necessary to understand the soil characteristics and parameters that, the soil properties of some delta' areas in Ayeyarwady Division are investigated and described in this paper.

## 2. Materials and Method

### Study Area

The three areas, two Reserve Forests (Meinmahla and Kadonkani) from the Bogalay township and one unclass Forests (Chaungtha) from the West Pathein Township are selected for the present study. The areas selected are almost flat planes and only a few feet above sea level in elevation. For a period of nearly 5 months during the rainy season (May to September), these areas are flooded. The weather is exclusively monsoon and the average annual rainfall is above 2000 mm. The minimum and maximum temperature is 20° Cand 35° C respectively and the relative humidity ranges from 43 to 97. The study area map is shown in Fig. I.

According to the Myanmar inventory forest classification; Meinmahla Reserve area is under 2b type, (medium class and medium density (970 %)) and Kadonkani Reserve area is under 1c type, (poor class and poor density (10-39%)), while Chaungtha area is Unclassed Forest type (personal Communication). The composition of tree species found in study sites are described in Table 1.

### Field Method

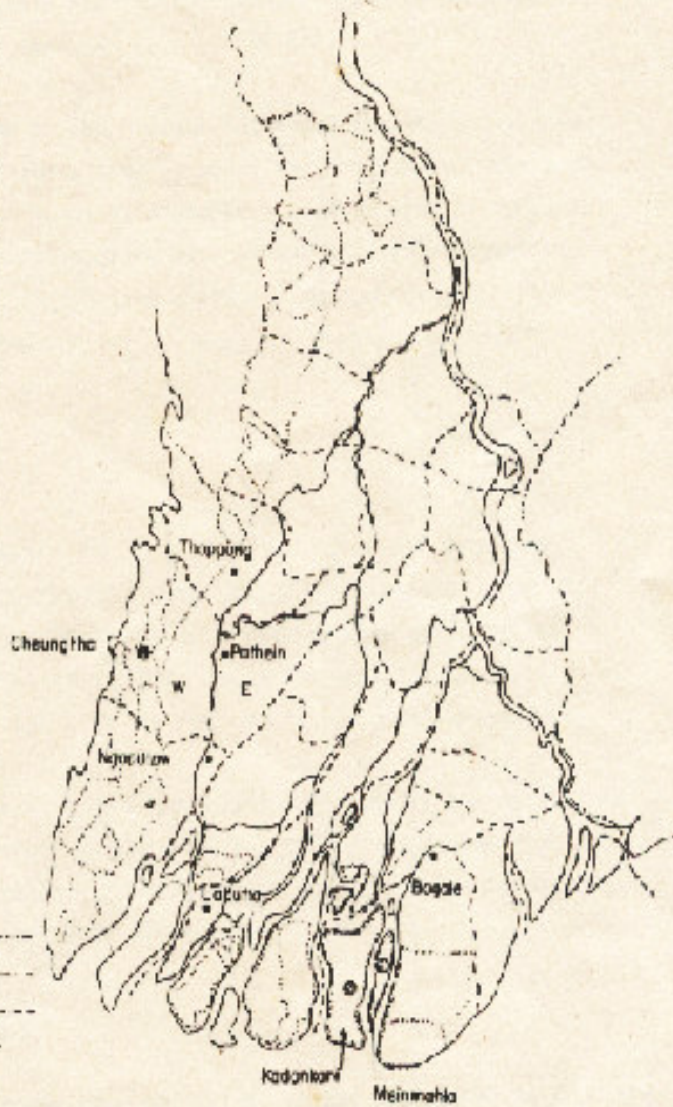
The suitable five locations were selected from each study area, and at five different depth (0-10 cm, 20-30 cm, 30-40 cm, 40-50 cm and 50-60 cm) soil samples were collected in each location. the sample were placed in separate labeled plastic bags and taken to the laboratory for chemical analysis.

Soil profiles were described according to the Guidelines for Soil Profile Description (F.A.O., 1977). Field description and sample collection were made during the dry season to ensure freedom from ground water disturbance.



Fig 1 Map of Study Area



Scale 1 inch = 32 miles



REFERENCES

- Myanmar Boundary -----
- State & Circle Boundary - - - - -
- Township Boundary - - - - -
- Forest Reserved Boundary  - - - - -
- Study area  - - - - -

### Laboratory Methods.

Soil samples were air-dried, ground and sieved to separate the fine earth (2 mm) from the coarse materials. The fine fraction was used for subsequent laboratory analysis.

**Table 1. List of major tree at species at (3) study sites**

Study Sites	Myanmar Name	Scientific Name
Meinma Hla Reserve Bogalay Township	Byu-u-talon	<i>Bruguiera conjugate</i>
	Byu-chidauk	<i>Rhizophora conjugate</i>
	Kanaso	<i>Baccaurea sapida</i>
	Kambala	<i>Sonneratia apetala</i>
	Kyana	<i>Carapa molluccensis</i>
	Khaya	<i>Acanthus iliciflious</i>
	Lamu	<i>Sonneratia caseolaris</i>
	Laba	<i>Sonneratia griffithii</i>
	Madama	<i>Ceriops roxburghiana</i>
	Momaka	<i>Salix tetrasperma</i>
	Myinga	<i>Cynometra mimosoides</i>
	Migyaungnwe	<i>Derris scandens</i>
	Pinleon	<i>Carapa abovata</i>
	Thayaw	<i>Excoecaria agallacha</i>
	Thakut	<i>Stereopermum glandulosum</i>
Zalat	<i>Enatamia coronaria</i>	
Kadonkani Reserve Bogalay township	Byu	<i>Dillenia aurea</i>
	Kyana	<i>Carapa molluccensis</i>
	Kanaso	<i>Baccausea sapida</i>
	Khaya	<i>Acanthus ilicifolius</i>
	Kyi	<i>Barringtonia acutangula</i>
	Kambala	<i>Sonneratia apeltala</i>
	Madama	<i>Ceriops roxburghiana</i>
	Myetkha	<i>Pennisetum hordeiforml</i>
	Pinleon	<i>Carapa obovata</i>
	Pyinma	<i>Lagerstroemia speciosa</i>
	Te	<i>Diospyros burmanica</i>
	Thayaw	<i>Excoecaria agallocha</i>
Thame	<i>Avicennia offiunalis</i>	
Chaung Tha West Pathein Township	Byu-u-talon	<i>Pruguiera conjugata</i>
	Byu-chidauk	<i>Phizophora conjugata</i>
	Kanaso	<i>Baccaurea sapida</i>
	Kyana	<i>Carapa molluccensis</i>
	Laba	<i>Sonneratia griffithii</i>
	Lamu	<i>Sonneratia acida</i>
Pinleon	<i>Carana obovata</i>	

Particle size distribution was carried out with the mechanical analysis with hydrometer method. Soil P<sup>H</sup> was determined in distilled water at a1:2:5 soil water ratio. The exchangeable bases of K, Ca, Mg and Na were extracted with double acid (Mehlich 1) and were measured by Perkin Elmer model 2280 atomic absorption spectrophotometer. Phosphorus in the double acid extract was determined by the molybdenum blue procedure

using ascorbic to develop the P color, which was then measured Perkin Elmer spectrophotometer 55.E at wave length 660 mm.

Total Nitrogen (Kjeldhal Nitrogen) were assessed by Kjeldhal method by using Labconco macro Kjeldhal, digestion and distillation unit. Electrical Conductivity (E.C) were measured by soil-water suspension as ratio 1:25 and stand for one hour stirring at regular intervals. Readings were made in m/mhos per centimeter by using Model 81 Conductivity Pridge Organic Matter was determined by loss on Ignition method at 550° C and ignited for two hours.

### **3. Result and Discussion**

Soil chemistry data and soil profile description (Morphology data) for the three study sites are shown in Table 2 and 3. Aspur of Pegu Anticline with Miocene shale and sand stone, extends to the south as far as Yangon, where it also disappear under the Ayeyarwadi further to the south. Close to the coast in the Tenasserim coastal area, recent and sub- recent fluviatile sediments lie directly on top of paleozoic schist, argillite, grewacks, sand- stone, quartzite and limestone or above granitic rocks (Bender F, 1983).

The soil from Meinmahla and Kadonkani Reserve are found to have more than 45 percent of clay content and above 30 percent of silt and 1-12 percent of sand while the soil of Chaungtha has 3-17 percent of clay and 50 percent of silt and 19-30 percent of sand. The soils from those study areas have good structure and fine texture. The texture and structure does not change with increasing depth in all sites.

The slightly acid and high level of nutrients contents of soils were found in the areas. the nutrient content was not notably different in layer by layer, however, nitrogen content decrease with increasing depth and organic matter percent had the same trend as nitrogen. A slight increase was found in Phosphorus and Potassium and also with increasing depth. Increasing Calcium, Sodium concentration and Electrical Conductivity (E.C) was found with the increasing of depth.

The soil from Kadonkani Reserve area was slightly acid and had high organic matter content and high level of nutrients concentration. All nutrient contents of different depths had almost the same concentration except a slight decrease in the nitrogen with the increasing depth. The little variation in the E.C was found in different depths.



**Table 2. Morphology of Delta Soils in Ayeyarwady Division.**

Description	Depth Horizon (cm)		(Color moist) Matrix Mottles			Texture			Structure	Constance & Plasticity		Boundary	Others	
						Sand	Silt	Clay						
Ayeyarwady Div. Bogalay Township Menimahla Reserve	0-10	A	10 YR5/3	25YR4/6	clay loam	12	32	50	granular	Stricky & very plastic	Clear, smooth	Bushes & shrubs		
	10-20	A <sub>1</sub>	10YR5/3	25YR4/6	clay	8	34	48	granular	`	Clear, wavy			
	20-30	A <sub>2</sub>	10YR4/3	-	clay	9	38	47	granular	`	Clear, wavy	Roots & branches		
	30-40	E	10YR5/3	-	clay	9	36	49	granular	`	Clear, wavy	Decays are in upper layer		
	40-50	B	10YR5/4	-	clay	7	40	47	granular	`	Clear, wavy	Reduction of Iron compounds are found		
	50-60	B	10YR5/3	-	clay	3	42	51	granular	`	Clear, wavy			
Ayeyarwady Div.  Bogalay Township	0-10	A <sub>1</sub>	10YR6/3	25YR4/6	clay	10	38	45	granular	Sticky & plastic	Gredual smooth	Some area are preforest and now farm land		

Description	Depth		(Color moist) Matrix Mottles			Texture			Structure	Constance & Plasticity	Boundary	Others		
	Horizon	(cm)				Sand	Silt	Clay						
Kadonkani Reserve	10-20	A <sub>2</sub>	10YR3/3	-	clay	5	40	45	granular	Sticky & plastic	Gredula smooth	Some area are preforest and now farm land		
	20-30	A <sub>3</sub>	7.5 YR5/4	-	clay	7	40	45	granular	`	Clear, smooth			
	30-40	B	10YR5/4	-	clay	6	40	45	granular	`	Clear, wavy			
	40-50	B	10 YR5/4	-	clay	1	40	52	granular	`	Clear, wavy			
	50-60	B	10YR5/4	-	clay	5	36	51	granular	`	Clear, wavy			
Ayeyarwady Div.	0-10	A <sub>1</sub>	7.5 YR5/4	25YR4/6	silt loam	19	52	17	granular	nonstick & non plastic	Clear, wavy	Large roots		
West Pathein Township	10-20	A <sub>1</sub>	10YR4/3	`	`	27	52	7	`	`	Abrupt, wavy	Decay roots are found in the upper		
Chaung Tha	20-30	A <sub>3</sub>	10YR3/1	`	`	32	50	3	`	`	`			
Unclass	30-40	A <sub>3</sub>	10YR3/1	`	`	30	53	3	`	`	`	Horizon		
Forest	40-50	B	10YR3/1	`	`	30	53	3	`	`	`	Soil are all swamps		
	50-60	B	10YR3/1	`	`	30	53	3	`	`	`			

**Table 3. Soil Chemical data from three study areas.**

Description	Depth (cm)	pH H <sub>2</sub> O (1: 2: 5)	O.M%	Total Extractable nutrients						Electrical Conductivity m mhos/cm
				N	P	K	Ca	Mg	Na	
				mg	Kg <sup>-1</sup>					
Ayeyarwady Div., Bogalay Township Meinmahla Reserve	0-10	6.8	5.8	1368.0	27.0	237.0	570.0	3430.0	3900.0	2.5
	10-20	6.9	5.9	1269.0	23.0	261.0	520.0	1010.0	3500.0	5.2
	20-30	6.9	7.2	1264.0	26.0	241.0	490.0	970.0	3700.0	5.3
	30-40	6.6	4.9	2330.0	32.0	207.0	530.0	690.0	4500.0	11.3
	40-50	6.6	4.0	848.0	36.0	210.0	610.0	880.0	5100.0	12.0
	50-60	6.6	4.1	871.0	35.0	283.0	710.0	210.0	4400.0	10.9
Ayeyarwady Div., Bogalay Township Kadonkani	0-10	6.4	7.4	1807.0	23.0	175.0	1110.0	1300.0	4000.0	5.4
	10-20	6.7	8.7	1757.0	trace	171.0	1430.0	1500.0	3800.0	4.1
	20-30	6.6	7.2	1781.0	22.0	179.0	1180.0	1800.0	3600.0	18.6
	30-40	6.7	6.8	1679.0	23.0	199.0	930.0	1000.0	4100.0	5.1
	40-50	6.8	7.2	1570.0	22.0	194.0	1010.0	900.0	4000.0	2.6
	50-60	6.7	7.5	1589.0	19.0	199.0	1130.0	900.0	4200.0	7.4
Ayeyarwady Div., West Pathein Township	0-10	5.5	14.2	2405.0	trace	9300.0	833.0	2290.0	770.0	2.8
	20-30	4.9	16.9	2236.0	trace	9200.0	222.0	2570.0	770.0	2.8
	30-40	3.7	17.54	2314.0	1.0	7390.0	270.0	2880.0	770.0	3.0
Chaung Tha Unclass Forest	40-50	3.9	14.2	2206.0	trace	7410.0	220.0	2100.0	770.0	3.0
	50-60	3.8	11.3	2102.0	trace	7200.0	210.0	2390.0	770.0	2.8

**Table 4. Properties of Sea Water at Study Areas.**

Sites	Nutrients (ppm)					
	p <sup>H</sup>	N	P	K	Na	E.C mmhos/cm
Chaungtha	8.5	nil	nil	433	200	18
Meinmahla & Kadonkani	8.4	nil	nil	165	200	19

Comparing to other two study areas more acidic soil and the highest organic matter contents were found in Chaungtha. Most of the nutrients concentration were higher, however, very low concentration of phosphorus was found in it. The Magnesium and Sodium concentrations did not change with depth. The low concentration of Potassium and Calcium were found in the deeper layers.

The soil properties on different location on each study areas were not different within the same Reserve (Appendix I). Some variations were found the E.C however, all units were of high level. In comparison within the same township; Meinmahla and Kadonkani Reserve, the Physical properties and p<sup>H</sup> were the same and small difference was found in the concentration of Potassium, Calcium and Magnesium.

It was found the soil properties in Chaungtha area of west Pathein Township was different from Bogalay Township. The soil in that area has silt loam texture and more acidity than that of Bogalay Township. The higher organic matter, Nitrogen and Potassium content was found in Chaungtha than in other areas, but the Phosphorus concentration was very trace in Chaungtha. The Sodium, Magnesium and Calcium concentration in Chaungtha were lower than those in the areas from Bogalay Township.

Mangrove soils are under the influence of tidal brackish of salt water, hence the soil salinity is high. The soil salinity as Electrical Conductivity, of mangrove soil is more than 4 m mhos/cm at 25°C (Sarwona Harjowigeno, 1986). The range of Electrical Conductivity of the study areas at Meinmahla and Kadonkani was between 4.1-18.6 m mhos/cm and between 2.8-3.0 m/mhos/cm at Chaungtha. So it was found that the common range of Electrical Conductivity is present at the Bogalay Township while it was lowered at West Pathein Township. Difference in salinity indicates different type of Mangrove with different species composition (Teas,1979). The soil salinity of Chaungtha area has less than 4m mhos/cm. However, the soils of Bogalay township are higher than 4 m mhos/cm . In this study it was found that different salinity indicates the different species composition (Table-3).

Freshly deposited alluvium at the seaward fringe of Indo-Pacific Mangrove, in the Aviceniazone, may contain only 5-15 organic matter (measured as loss of weight on ignition), whereas the more mature mangrove soil in the upper levels of a forest may have 65% or more organic matter (Macnae,1968). In south Florida where the calcareous sand along the shore can be 7% organic, the soil of mature. Rhizophora forest averaged 28% organic, and Avicenia forest was 25%, organic and the induced laguncularia forest on the marl soil of former tomato fields was 13% organic matter (Teas, 1974). It was found that the organic matter content of Chaungtha are has 5-15 % and 4-9 % at Meinmahla, Kadonkani. It also indicate the different species composition.

#### **4. Conclusion**

Mangrove Forest soils, at all study sites, have favourable condition of Physical and Chemical properties and satisfactory levels of primary plant nutrients for tree growth . But it indicated that further investigation of Mangrove soil is required and the studied should adhere to the following points.

- (1) The relationship between soil properties and natural regeneration should be investigated so that more information can be obtained to assist in the planning of forest plantations.
- (2) The ripeness value of Mangrove soils is helpful in predicting whether the soil is able to support load to the degree of subsidence that would occur after drainage. To calculate the ripeness of the Mangrove soils of the study sites, the percentage of water in soil in field condition need to be investigated.
- (3) In this study, it deals only with the Mangrove forest type of 2b and 1c classes and hence it indicate that; the investigation need to extend the other classes of Mangrove forest.

**Appendix 1. Soil Chemistry Data from study areas.**

Description	Depth (cm)	pH H <sub>2</sub> O (1:2.5)	Organic Matter %	Total		Extractable Nutrients			Electrical Conductivity m mhos/ cm	
				N	P	K	Ca	Mg		Na
				mg kg <sup>-1</sup>						
Profile I										
Ayeyarwady Div.,	0-10	6.9	4.7	1285.0	28.6	225.2	570.0	990.0	3800.0	0.7
Bogalay Township	10-20	6.8	8.4	1294.0	28.2	233.4	560.0	1030.0	3200.0	0.9
Meinmshla Reserve	20-30	6.9	5.2	884.0	28.4	244.8	390.0	900.0	4600.0	9.3
	30-40	6.4	4.5	894.0	36.0	109.6	490.0	970.0	4200.0	11.3
	40-50	6.6	5.2	811.0	37.3	255.4	520.0	900.0	5800.0	11.6
	50-60	6.6	4.6	813.0	39.9	277.4	580.0	2700.0	5400.0	10.0
	Profile II									
	0-10	6.8	5.1	1167.0	24.8	235.4	600.0	1000.0	4400.0	4.0
	10-20	6.9	5.0	860.0	23.9	249.4	460.0	1020.0	4300.0	13.2
	20-30	7.0	12.1	2007.0	17.4	242.2	610.0	1000.0	3400.0	3.3
	30-40	6.7	4.3	793.0	35.2	237.8	480.0	800.0	4600.0	12.5
	40-50	6.6	2.8	807.0	38.6	266.0	580.0	900.0	5000.0	12.5
	50-60	6.9	5.1	956.0	37.3	287.6	820.0	2200.0	4400.0	11.7
Profile III										
	0-10	6.9	5.6	1487.0	27.7	235.2	600.0	1030.0	3400.0	0.4
	10-20	7.0	4.5	1105.0	18.7	274.4	640.0	900.0	3600.0	7.3
	20-30	6.8	6.2	1089.0	27.2	242.6	480.0	1010.0	4100.0	6.3
	30-40	6.6	5.4	916.0	26.7	237.8	560.0	800.0	5100.0	9.0
	40-50	6.6	2.9	777.0	35.8	269.8	410.0	600.0	6300.0	12.3
	50-60	6.7	4.8	847.0	34.6	274.8	940.0	2100.0	5100.0	12.0

**Appendix 1. Condt.**

Description	Depth (cm)	p <sup>H</sup> H <sub>2</sub> O  (1:2.5)	Organic Matter %	Total			Extractable Nutrients			Electrical Conductivity m mhos/ cm
				N	P	K	Ca	Mg	Na	
				mg kg <sup>-1</sup>						
			Profile IV							
Ayeyarwady Div.,	0-10	6.8	6.1	1319.0	28.8	232.2	580.0	14000.0	4500.0	3.9
Bogalay Township	10-20	7.0	6.5	1541.0	20.5	281.0	500.0	1200.0	3300.0	3.3
Meinmahla Reserve	20-30	6.9	8.1	1602.0	27.9	256.0	500.0	1000.0	2400.0	3.3
	30-40	6.6	5.1	780.0	29.0	236.4	600.0	800.0	4100.0	11.8
	40-50	6.6	3.9	847.0	36.6	286.0	970.0	1300.0	4400.0	12.5
	50-60	6.6	2.8	934.0	33.6	300.8	630.0	2300.0	3700.0	11.5
				Profile V						
	0-10	6.7	7.4	1580.0	24.7	257.8	520.0	130.0	3400.0	3.3
	10-20	7.1	5.0	1047.0	22.8	268.4	450.0	900.0	3200.0	4.3
	20-30	6.7	4.1	738.0	30.1	217.8	480.0	920.0	3300.0	3.8
	30-40	6.6	5.3	8767.0	35.3	212.0	550.0	110.0	4900.0	11.8
	40-50	6.6	5.1	987.0	33.8	280.2	580.0	700.0	3800.0	11.0
	50-60	6.7	2.9	800.0	33.5	272.0	590.0	1200.0	3600.0	9.4
			Profile I							
Ayeyarwady Div.,	0-10	6.7	6.4	1677.0	24.9	170.0	1070.0	1170.0	3300.0	5.8
Bogalay Township	10-20	6.6	8.9	1885.0	Trace	174.0	1740.0	1760.0	3300.0	0.6
Kadonhanyi Reserve	20-30	6.7	5.8	1658.0	21.5	174.0	1260.0	4000.0	3800.0	1.2
	30-40	6.6	7.8	1669.0	21.4	-	-	-	-	0.6
	40-50	6.9	6.9	1352.0	20.6	189.0	1000.0	1120.0	4400.0	0.1
	50-60	6.6	6.6	1576.0	18.7	192.0	1080.0	960.0	3700.0	7.5

**Appendix 1. Condt.**

Description	Depth (cm)	pH H <sub>2</sub> O (1:2.5)	Organic Matter %	Total		Extractable Nutrients			Electrical Conductivity m mhos/ cm	
				N	P	K	Ca	Mg		Na
				mg kg <sup>-1</sup>						
Profile II										
Ayeyarwady Div.,	0-10	6.4	8.3	1890.0	18.5	183.0	1250.0	1690.0	3900.0	7.6
Bogalay Township	10-20	6.7	9.1	1817.0	Trace	167.0	1410.0	1500.0	3800.0	0.5
Kadonkani Reserve	20-30	6.8	6.1	1640.0	19.4	171.0	1100.0	1260.0	3700.0	0.8
	30-40	6.6	7.9	1796.0	24.8	182.0	980.0	1100.0	4000.0	0.4
	40-50	7.0	7.2	1510.0	28.2	168.0	960.0	880.0	3600.0	0.2
	50-60	6.7	8.9	1534.0	18.0	194.0	1080.0	900.0	3800.0	6.9
Profile III										
	0-10	6.2	7.3	1794.0	22.4	168.0	1150.0	1210.0	4400.0	3.5
	10-20	6.8	9.2	1913.0	trace	167.0	1370.0	1320.0	3100.0	0.4
	20-30	6.4	7.3	1874.0	19.9	176.0	1220.0	1220.0	3800.0	6.3
	30-40	6.9	5.9	1758.0	23.7	243.0	910.0	900.0	4900.0	0.6
	40-50	6.5	8.2	1783.0	23.8	230.0	1080.0	900.0	4000.0	0.2
	50-60	6.9	7.3	1432.0	18.7	202.0	1120.0	930.0	5000.0	4.5
Profile IV										
	0-10	6.7	6.0	1705.0	24.5	174.0	1120.0	1410.0	4900.0	7.7
	10-20	6.6	8.3	1536.0	trace	176.0	1400.0	1680.0	4000.0	0.3
	20-30	6.8	8.5	1963.0	20.9	221.0	1380.0	1410.0	3500.0	0.6
	30-40	6.9	5.1	1492.0	25.1	-	-	-	-	0.7
	40-50	6.9	7.1	1411.0	19.5	191.0	960.0	920.0	4000.0	0.4
	50-60	6.0	7.3	1450.0	19.6	206.0	1170.0	900.0	4200.0	7.7



**Appendix 1. Condt.**

Description	Depth (cm)	pH H <sub>2</sub> O (1:2.5)	Organic Matter %	Total			Extractable Nutrients			Electrical Conductivity m mhos/ cm
				N	P	K	Ca	Mg	Na	
				mg kg <sup>-1</sup>						
			Profile V							
Ayeyarwady Div.,	0-10	6.2	9.0	1970.0	trace	178.0	970.0	1020.0	3100.0	2.5
Bogalay Township	10-20	6.7	8.3	1638.0	trace	172.0	1210.0	1310.0	3700.0	0.3
Kadonkani Reserve	20-30	6.6	7.9	1768.0	27.5	157.0	960.0	870.0	3100.0	0.5
	30-40	6.7	7.1	1684.0	20.9	1710.0	910.0	840.0	3300.0	0.3
	40-50	6.6	6.5	1794.0	17.2	190.0	1040.0	920.0	4200.0	0.4
	50-60	7.0	7.6	1957.0	trace	204.0	2220.0	990.0	4400.0	5.3

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