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Monitoring the Changes of Redox Potential, pH and Electrical Conductivity of the Mangrove Soils in Northern Taiwan

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ABSTRACT

The redox potential (Eh), pH and electrical conductivity (EC) of the marsh soils of the Chuwei mangrove, located in the estuarine of the Tansui River in northern Taiwan were monitored for two years (from October 1995 to September 1997). The soils of selected pedons were studied, and the soils were classified based on *Keys to Soil Taxonomy*. The soil pH values tended to be neutral due to the impact of seawater on the mangrove marsh. The amounts of organic carbon found in this study area were much less than those generally encountered in the wetland soils of temperate regions in the world. The base saturation percentages of the soils were almost 100%, the exchangeable Na being particularly predominant. The concentrations of various cations of water in this ecosystem were in the order of $Na^+ > Mg^{2+} > K^+ = Ca^{2+}$, and those of anions of water were in the order of $Cl^- > SO_4^{2-} > NO_3^- > PO_4^{3-}$. In spite of seasonal flooding changes, highly reduced states (100 to –200 mV of Eh values) existed throughout the two-year study. The spatial and temporal variations of the Eh values of the surface soil (0 – 20 cm) were higher than those of the subsoils (20 – 100 cm). The EC values of the soils from the surface to a depth of 100-cm were generally more than 20 dS/m. The marsh soils of the Chuwei mangrove were, thus, classified as Halic Endoaquents or Halic Fluvaquents.

Key Words: mangrove soil, redox potential, electrical conductivity, soil classification

I. Introduction

The ecological and other functions of the mangrove marsh wetlands have been previously recognized (Hseu *et al*., 1996). The mangrove ecosystem is an association of halophytic trees, shrubs, and other plants that grow in brackish to saline tidal waters of tropical and subtropical coastlines. Mangrove means the marsh is dominated by *Rhizophoraceae*, and marsh means the habitat has a mineral soil substrate and does not accumulate peat. Mangrove soils are found along intertidal shores and estuarines in the tropics. The soils in the mangrove marsh are often highly reduced, with redox potentials (Eh) ranging from –100 to –400 mV (Mitsch and Gosselink, 1993), due to flooding from rivers and the sea. Seasonal variability in soil salinity is a function of the height and duration of tides and rainfall, and the amount of fresh water that enters the mangrove marsh from rivers, creeks, and runoff (Clark and Juve, 1962).

The parent materials of mangrove soil in a tidal marsh are alluvial materials in the sedimentary environment (Bescansa and Roquero, 1990). The input, output and transformation of nutrient elements in mangrove soil, which are enriched by sodium, magnesium, and sulfur associated with hydrological conditions, have a major impact on the biogeochemical processes in this ecosystem. Mangrove soils in a tidal marsh were previously classified as Entisols or Histosols (Ukpong, 1995; Soil Survey Staff, 1998). A few studies have been conducted on the soil properties of mangroves in Taiwan (Chen, 1994). Shyue (1995) investigated the vegetation distributions in mangroves on west coast of Taiwan. The soil characteristics and hydrological dynamics of the mangrove soils in Taiwan are needed to interpret the biogeochemical processes of this ecosystem. The objectives of this study were (1) to explain the profile distributions of the Eh, electrical conductivity (EC), and pH in the soils of a mangrove marsh, (2) to verify the physical and chemical properties of the representative mangrove soils pedons in northern Taiwan, and (3) to propose a classification of mangrove soils in

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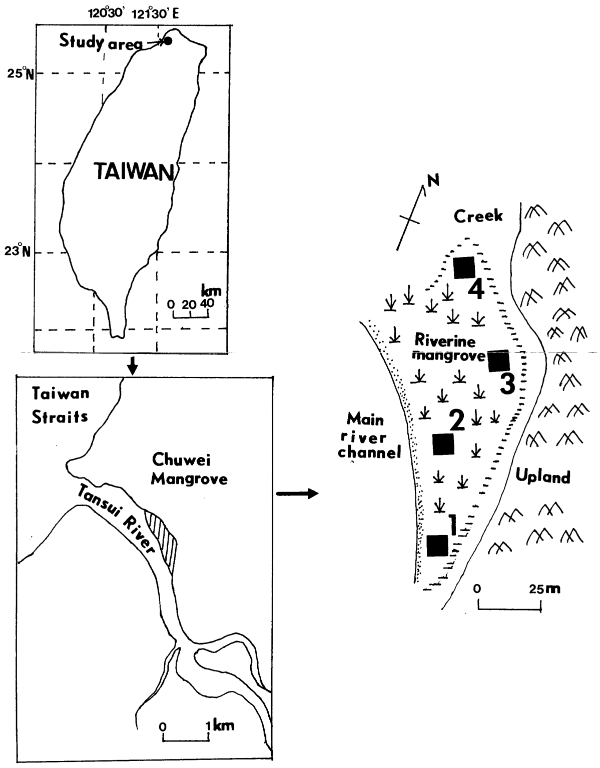

Fig. 1. Location of the Chuwei mangrove, northern Taiwan. Four pedons (1 – 4) were also selected in this study.

Taiwan based on *Keys to Soil Taxonomy*, which emphasizes the moisture regime in its higher categories and the crucial attribute in its lower categories of soils (Soil Survey Staff, 1998).

II. Materials and Methods

1. Geographic Setting of Study Area

Chuwei mangrove is the largest mangrove marsh in Taiwan with a total area of approximately 50 ha. It is located in the estuarine of the Tansui River in northern Taiwan, nearly 20 km from Taipei City (Fig. 1). The riverine mangrove area was selected for this study. *Kandelia candel* Druce, *Avicennia marina* (Forsk.) Vierh, *Rhizophoara mucronata* Lam., and *Lumnitzera racemosa* Willd. are the dominant species of mangrove in Taiwan, but only *Kandelia candel* Druce is a primary species in the Chuwei mangrove (Shyue, 1995). The mangrove soils are mostly composed of alluvial materials from upstream river water delivered to stabilize the ecosystem substrate over the last few hundred years (Hseu *et al.*, 1996). The annual rainfall in the study area is about 2,500 mm, with most of the rainfall occurring in the summer. The average air temperature is 25 – 27°C in summer and 17 – 20°C in winter. The mean tidal ranges between spring tides and neap tides are approximately 2 – 3 meters for the estuarine of the Tansui River (Huang, 1983). During a rising tide, the overflowing water spreads back downstream over the marsh suface.

2. Laboratory Analysis

Four soil pedons were sampled from the surface to a depth of 100 cm at intervals of 20 cm to understand the spatial variability of the soil properties (Fig. 1). Pedon 1 is located at the entrance of the riverine mangrove, with more tidewater and riverflow influence on the soil. Pedons 2 and 3 are located in the center of the riverine mangrove. Pedon 4 is least affected by water since it is located at the exit zone of the riverflow.

Air-dried samples from the four pedons were collected for selected physical and chemical analysis. Particle size distribution was determined using the pipette method (Gee and Bauder, 1986) while soil pH was measured using a glass electrode (McLean, 1982). Organic matter content was measured using the modified Walkley-Black wet oxidation method (Nelson and Sommers, 1982), and the cation exchangeable capacity (CEC) and exchangeable bases (K^+, Na^+, Ca^{2+}, and Mg^{2+}) were measured using the ammonium acetate method (pH 7.0) (Rhoades, 1982).

Surface water was sampled from the coastal creek along the riverine mangrove during different seasons of 1997. Selected cations analyzed by means of atomic absorption spectrophotometry (AAS) (Hitachi, Japan, 180-30 type) and anions analyzed using ion chromatography (IC) (Dionex, U.S.A., 2000I) included K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}.

3. *In Situ* Monitoring of Eh, pH, and EC of Soils

Eh was measured *in situ* in the field with a platinum electrode and an AgCl reference electrode in fresh soil cores collected at depths of 20-, 40-, 60-, 80-, and 100-cm sampled using an auger. The EC (dS/m) and pH of the saturated paste of fresh moist soil samples collected at the same depths were also measured in the field. Eh, EC, and pH measurements were conducted every two weeks for two years (from October 1995 to September 1997).

III. Results and Discussion

1. Physical and Chemical Properties of the Mangrove Soils

The hues of the matrix colors of the mangrove soils in this study were dark gray and deep olivine because the soils had been waterlogged for a long time. Submergence caused soil inconsistency. Silt was the dominant particle size of the soils since it ranged from 54 to 72% throughout all the horizons of the four pedons. Sand only occupied

Table 1. Selected Physical and Chemical Properties of Soil Pedons in the Study Area

Depth cm	Horizon	Texture			pH	O.C.[a]	CEC[b]	Exch. Bases[c]				BSP[d]	ESP[e]
		Sand	Silt	Clay				K^+	Na^+	Ca^{2+}	Mg^{2+}		
		-------	%	-------		g/kg	------------------------------	cmol(+)/kg			--------------------	----- %	-----
						Pedon 1							
0 – 20	A	14	62	24	7.1	15.5	10.5	0.5	7.6	0.4	1.8	99	72
20 – 40	C1	18	56	26	7.0	27.2	11.1	0.5	6.9	0.5	1.7	87	62
40 – 60	C2	11	63	27	7.1	15.5	9.7	0.5	7.2	0.4	1.7	100	75
60 – 80	C3	14	60	26	6.7	15.5	10.0	0.6	9.0	0.5	1.8	100	90
80 – 100	C4	4	72	24	6.6	19.4	10.5	0.6	8.6	0.5	0.2	95	82
						Pedon 2							
0 – 20	A	13	62	25	7.0	22.5	11.0	0.6	8.3	0.7	2.0	100	66
20 – 40	C1	16	54	30	6.8	23.3	11.1	0.6	7.9	0.7	1.8	99	71
40 – 60	C2	11	61	28	6.6	23.3	11.6	0.6	7.6	0.6	1.7	91	66
60 – 80	C3	15	60	25	6.6	23.3	12.6	0.6	9.7	0.6	2.1	100	77
80 – 100	C4	13	63	24	6.5	18.7	10.2	0.6	10.4	0.4	2.1	100	100
						Pedon 3							
0 – 20	A	10	60	30	6.6	26.4	14.2	0.6	7.9	0.6	2.1	79	56
20 – 40	C1	11	59	30	6.5	26.4	13.3	0.6	9.3	0.6	2.0	94	70
40 – 60	C2	11	58	31	6.4	24.9	13.3	0.7	10.7	0.5	2.5	100	81
60 – 80	C3	6	61	33	6.4	31.1	11.7	0.7	11.8	0.5	2.5	100	100
80 – 100	C4	6	65	29	6.4	24.9	11.3	0.7	10.7	0.6	2.1	100	95
						Pedon 4							
0 – 20	A	9	62	29	6.5	15.5	12.6	0.4	3.0	0.5	1.5	43	24
20 – 40	C1	11	60	29	6.6	15.5	12.6	0.4	1.6	0.7	1.3	31	13
40 – 60	C2	7	63	30	6.2	15.5	13.0	0.4	2.0	0.5	1.3	33	15
60 – 80	C3	7	64	29	6.1	17.1	12.2	0.5	5.1	0.5	1.7	64	42
80 – 100	C4	8	64	28	6.1	15.5	12.1	0.4	3.0	0.7	1.5	46	25

[a] Organic carbon.
[b] Cation exchange capacity.
[c] Exchangeable bases.
[d] Base saturation percentage.
[e] Exchangeable sodium percentage (Ex. Na/CEC) × 100%.

Table 2. Analysis of Surface Water in the Study Area During 1997

Date	K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	NO_3^-	PO_4^+	SO_4^{2-}
	------------------------------			g/L			---------------------------------	
14 Feb	0.20	5.00	0.18	0.56	4.81	0.02	ND	1.04
14 Mar	0.19	4.83	0.19	0.59	5.21	0.02	ND	1.50
18 Apr	0.27	6.10	0.25	0.90	6.04	0.02	ND	1.82
29 May	0.31	6.68	0.37	0.94	6.74	0.01	ND	1.73
25 Jul	0.38	6.65	0.44	1.13	6.63	0.02	ND	1.84
22 Aug	0.27	5.45	0.36	0.77	5.56	0.02	ND	1.87

Note: ND: Not detectable (PO_4^{3-} < 0.01 mg/L).

< 20% of all the soils (Table 1), and there was no evidence of clay accumulation in these soils.

All the soil pH (water) values tended to be neutral due to the influence of seawater. In addition, the pH values decreased with increasing soil depth because of weak leaching through the soil profile and soil flooding by tide water (Table 1). The accumulation of organic matter in wetland soils is much more pronounced than it is in upland soils. Coultas (1980) found that the marsh soils in the estuaries of Florida contain more than 10% organic matter, while Hill (1982) found that those in Connecticut have close to 30%. Although frequent runoff by river and seawater resulted in the removal of litter from the forest wetland in this study, organic carbon was almost always less than 30 g/kg in all the soils while the mean value of organic carbon in the arable soils of Taiwan is 20 g/kg. Sodium is the crucial factor affecting the soil properties of the mangrove marsh. For example, high soil pH values and high base saturation percentages were attributed to the presence of highly exchangeable sodium in the soils. High Na^+ concentrations were present in the surface water during the two year period of the study (Table 2).

The magnesium contents in both the soil and surface water were much higher than those of potassium and calcium (Tables 1 and 2). The influx of seawater from the spring tides resulted in major inputs of selected cations, which were then adsorbed by the soil or taken up by the roots of the mangroves, changing the level of physiological adaptability to osmosis stress, especially in the case of sodium ion (Huang, 1983). However, the concentrations of various cations in the soil and surface water were in the order of $Na^+ > Mg^{2+} > K^+ = Ca^{2+}$. Chloride and sulfate ions detected in the soils came mostly from seawater while nitrate found in the surface water probably came from various pollution sources upstream in the Tansui River (Table 2). The concentrations of various anions in the surface water were in the order of $Cl^{-} > SO_4^{2-} > NO_3^{-} > PO_4^{3-}$.

2. Seasonal Fluctuations of Eh, pH, and EC

In the soils from the surface to a depth of 100-cm, a highly reduced status of redox potential was found, ranging from 100 to –200 mV. For example, the Eh values of the surface soil (0 – 20 cm) were always less than 100 mV and were below zero mV (Fig. 2) most of the time. The standard deviations (STD) and coefficients of the variation (CV%) of the Eh, pH, and EC values in each month were determined by reading the data for each depth at each pedon as illustrated in Tables 3 – 5. The mean data were calculated from triplicate values in two years. The large temporal and spatial variations in the Eh values reflect seasonal fluctuation due to rainfall and tide action; the input and output of water strongly influenced the Eh readings. Of the three field monitor items, only the spatial variations of the Eh measurements increased with decreasing soil depth (Table 3). The standard deviations of the Eh values with replicates in the surface soils (0 – 20 cm) ranged from 25 to 200 mV while those of the other subsoils ranged from approximately 6 to 90 mV. On the other hand, the CV(%) of the soil Eh within a depth of 40 cm was much higher than that of the soils from 40 cm to 100 cm. Less rainfall, flooding time, and litter accumulation resulted in higher Eh values each spring (Table 3). On the contrary, lower Eh values were found from June to September because of the larger amount of rainfall and large number of typhoon events (Table 3). The seasonal fluctuation of Eh values in the soils from 20 – 100 cm, showing a trend similar to that of the Eh values of the surface soils (0 – 20 cm) (Table 3 and Fig. 2). Thus, soil aeration and organic matter content are the two major crucial factors

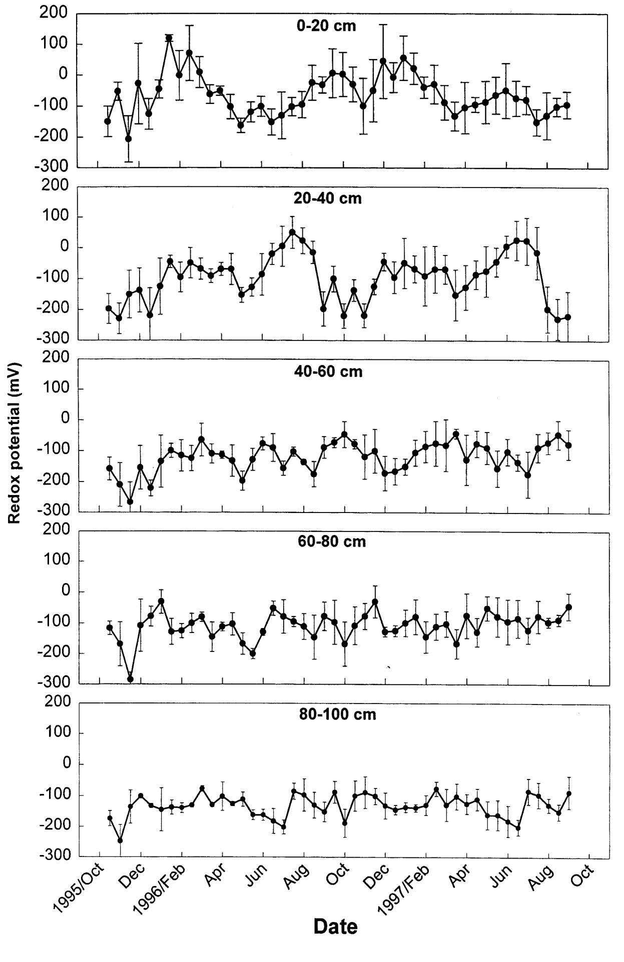

Fig. 2. The mean values of the redox potential and their variations at depths of 0 – 20, 20 – 40, 40 – 60, 60 – 80, and 80 – 100 cm in the four soil pedons of the Chuwei mangrove. (Vertical bars indicate standard deviations)

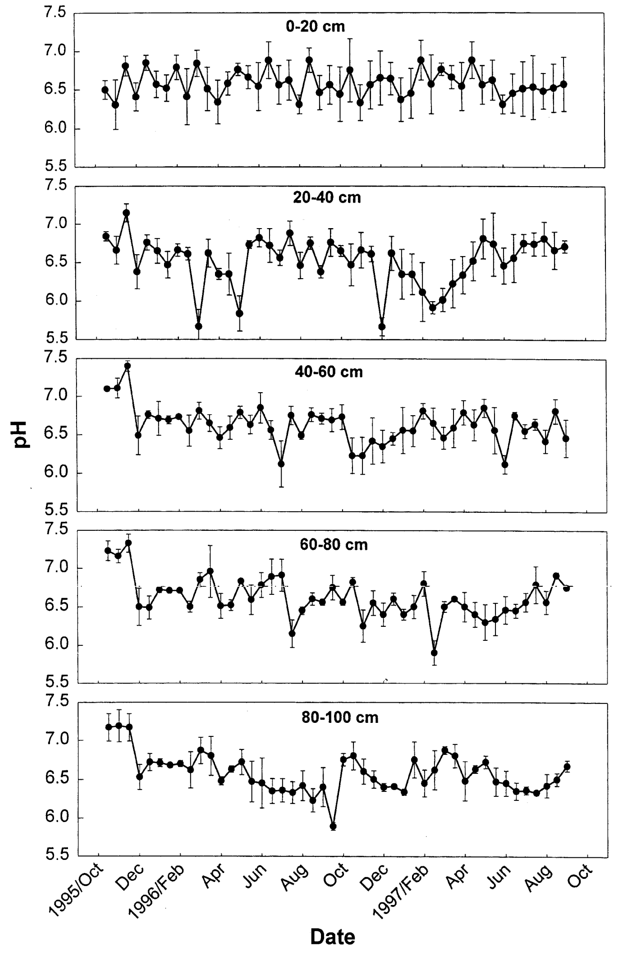

Fig. 3. The mean values of pH and their variations at depths of 0 – 20, 20 – 40, 40 – 60, 60 – 80, and 80 – 100 cm in the four soil pedons of the Chuwei mangrove. (Vertical bars indicate standard deviations)

Table 3. The Mean Values, STD and CV(%) of Eh Values (mV) at Different Soil Depths in the Study Area

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							0 – 20 cm					
Mean	31	15	–60	–98	–116	–108	–96	–100	–76	–48	–113	–39
STD	73	46	29	34	34	29	55	55	39	72	89	70
CV(%)	238	299	48	35	50	67	26	55	81	150	99	178
							20 – 40 cm					
Mean	–78	–68	–76	–105	–100	–37	26	–14	–212	–184	–169	–131
STD	38	17	13	42	49	39	19	30	13	59	44	71
CV(%)	49	25	17	40	49	106	72	209	6	32	26	54
							40 – 60 cm					
Mean	–50	–46	–62	40	41	43	35	–32	44	–42	51	–55
STD	25	6	28	33	9	16	27	16	7	23	31	21
CV(%)	50	13	45	82	22	37	78	50	16	55	61	38
							60 – 80 cm					
Mean	–88	–103	–122	–115	–139	–89	–95	–107	–72	–138	–158	–86
STD	43	31	22	38	65	32	19	29	23	36	112	42
CV(%)	49	30	18	33	47	36	20	27	32	26	71	49
							80 – 100 cm					
Mean	3	12	–73	27	–13	16	–212	–57	21	–138	–22	15
STD	3	28	30	11	28	16	25	30	41	66	25	19
CV(%)	98	231	41	41	21	70	26	53	79	48	86	129

Table 4. The Mean Values, STD and CV(%) of pH Values at Different Soil Depths in the Study Area

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							0 – 20 cm					
Mean	6.3	6.0	6.0	6.4	6.5	6.1	7.0	6.7	7.0	6.5	6.7	6.3
STD	0.19	0.24	0.12	0.13	0.13	0.18	0.14	0.18	0.07	0.13	0.18	0.19
CV(%)	3	4	2	2	2	3	2	3	1	2	3	3
							20 – 40 cm					
Mean	7.0	6.6	6.3	6.0	6.3	7.0	7.0	7.0	6.0	6.5	7.0	6.0
STD	0.14	0.40	0.38	0.06	0.44	0.14	0.16	0.16	0.18	0.09	0.35	0.48
CV(%)	2	6	6	1	7	2	2	2	3	1	5	8
							40 – 60 cm					
Mean	6.0	7.0	5.5	7.0	5.5	6.0	6.0	7.0	6.0	7.2	6.8	7.3
STD	0.12	0.15	0.11	0.14	0.11	0.30	0.30	0.15	0.18	0.23	0.68	0.22
CV(%)	2	2	2	2	2	5	5	2	3	3	10	3
							60 – 80 cm					
Mean	7.5	6.3	6.6	7.1	6.4	6.5	6.2	7.0	6.0	6.2	6.8	6.2
STD	0.15	0.19	0.53	0.05	0.23	0.26	0.31	0.14	0.18	0.32	0.54	0.06
CV(%)	2	3	8	1	4	4	5	2	3	5	8	1
							80 – 100 cm					
Mean	6.1	6.0	6.6	6.8	6.2	6.2	6.2	6.4	6.7	6.7	6.7	6.5
STD	0.19	0.18	0.13	0.15	0.12	0.05	0.12	0.09	0.14	0.61	0.29	0.13
CV(%)	3	3	2	2	2	1	2	1	2	9	4	2

that affect the redox potential in this ecosystem.

Ecosystems like oceans and estuaries resist acidification as their dissolved salts impart a large buffering capacity. Therefore, the fluctuation of the soil pH values in the study soil, especially for the surface soil, was less than one unit from 1995 to 1997 (Fig. 3). The STD and CV (%) of the soil pH values in the surface soil (0 – 20 cm) were less than those of the other subsoils (Table 4) due to direct exposure to seawater. At the same time, the standard deviations of the pH values of the soils from the surface to a depth of 100 cm were less than 0.5, and the coefficients of variation were less than 10% throughout the

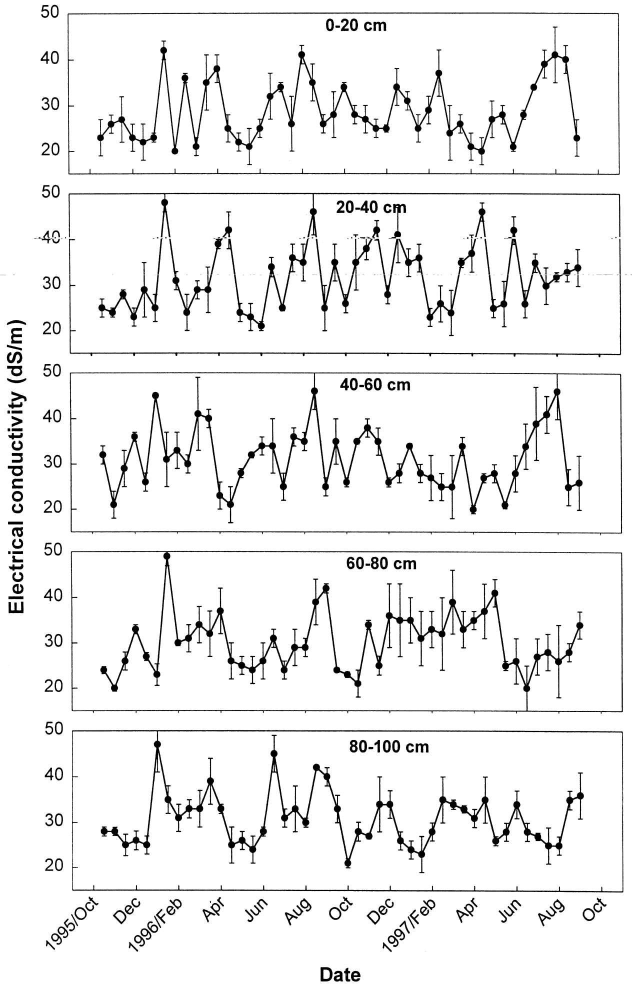

Fig. 4. The mean values of the electrical conductivity and their variations at depths of 0 – 20, 20 – 40, 40 – 60, 60 – 80, and 80 – 100 cm in the four soil pedons of the Chuwei mangrove. (Vertical bars indicate standard deviations)

two years. Dissolved salts, like Na^+ and Mg^{2+}, played an important role in buffering the pH change. The relative redox conditions may correlate with those of other wetland soils because the redox potential in soils is pH-dependent.

The EC values of the mangrove soils also varied with the season, but they usually remained above 20 dS/m (Fig. 4). High EC values are primarily attributed to sodium and magnesium from seawater. The data here indicated that the standard deviations of the surface soil EC values were higher in spring and summer than in autumn and winter (Table 5 and Fig. 4). This seasonal difference occurred because the larger amounts of rainfall and the freshwater from the upstream region of the Tansui River dilute the salt concentrations of the mangrove soil. The distributions of EC values, calculated by combining the standard deviations and coefficients of variations, in the soils were found to be random (Table 5).

3. Soil Classification

Soil hydrology has the greatest influence on the classification of mangrove marsh soils in Taiwan. Four of the studied pedons can be grouped as well as classified as Entisols or Aquents with aquic moisture regimes based on *Keys to Soil Taxonomy* (Soil Survey Staff, 1998). Pedons 1 and 4 can be classified as Endoaquents, and pedons 2 and 3 can be classified as Fluvaquents in Great Groups, especially in light of the organic matter distributed in Chuwei's mangrove soils.

The mangrove soils with Halic Subgroups of Endoaquents or Fluvaquents have all of the following characteristics defined in *Keys to Soil Taxonomy* (Soil Survey Staff, 1998):

(1) exchangeable Na^+ and Mg^{2+} > 40% of cation exchangeable capacity (CEC), which was extracted by a 1 M ammonium acetate (pH 7.0), or exchangeable sodium percentage (ESP) > 15%, and
(2) EC > 7 dS/m, and
(3) an Aquic moisture regime.

Coover *et al.* (1975) proposed that only those mangrove soils having a peraquic or aquic moisture regime and a Halic, Almyric, or Halmyric properties in more than half of the volume in the upper one-meter in the criteria of Halic Subgroup. These three Subgroups are proposed herein because of: (1) the flora and fauna's diverse response to soil salinity, and (2) the strong influence of the seawater which deposited Na^+ and Mg^{2+} on the soil properties.

Exchangeable Na^+ content was more than one half of the CEC values in pedons 1, 2, and 3, and ESP was more than 15% in pedon 4 (Table 1). Therefore, the sum of the exchangeable Na^+ and Mg^{2+} satisfies the criteria proposed in the Halic Subgroup. The EC values in the surface soils of 4 pedons were much more than 7 dS/m. Therefore, soils of the Chuwei mangrove can be grouped as Halic Endoaquents or Halic Fluvaquents.

IV. Conclusions

The Mangrove ecosystem adapts itself to the double stresses of flooding and salinity. The soil textures of the Chuwei mangrove are silt-like loam or silt-like clay loam. All the soil pH values tended to be neutral because the dissolved salts in the floodwater imparted a large buffering capacity, thus enhancing resistance to acidification. The amount of organic carbon in the Chuwei mangrove soils is much less than that found in other temperate region wetland soils. The concentrations of various cations of water in this ecosystem are $Na^+ > Mg^{2+} > K^+ = Ca^{2+}$, and those of anions are $Cl^- > SO_4^{2-} > NO_3^- > PO_4^{3-}$. Highly reduced conditions were maintained through the year despite seasonal flooding variations. However, the spatial and temporal variations of the surface soil (0 – 20 cm) in the Eh

Table 5. The Mean Values, STD and CV(%) of EC (dS/m) at Different Soil Depths in the Study Area

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							0 – 20 cm					
Mean	30	26	32	26	21	28	29	43	29	30	50	33
STD	8	6	7	7	3	5	4	3	9	5	1	2
CV(%)	27	23	22	27	14	18	14	7	31	17	2	6
							20 – 40 cm					
Mean	35	29	30	38	30	30	32	35	31	28	30	30
STD	9	6	3	3	11	9	6	7	5	5	5	8
CV(%)	26	21	10	8	37	30	19	20	16	18	15	27
							40 – 60 cm					
Mean	37	30	31	23	40	29	33	42	50	27	38	33
STD	7	6	9	6	2	6	6	5	1	6	5	6
CV(%)	19	20	29	26	8	21	18	12	2	22	13	18
							60 – 80 cm					
Mean	34	40	33	32	33	30	25	32	35	25	29	29
STD	11	2	4	5	9	3	4	6	7	2	7	5
CV(%)	32	5	12	15	27	10	16	19	20	8	24	17
							80 – 100 cm					
Mean	33	31	43	33	28	33	33	31	43	28	33	30
STD	9	5	3	4	5	8	3	8	3	5	2	5
CV(%)	27	16	7	12	18	24	9	26	7	18	6	17

values distinguished by STD and CV(%) were much more than those in other subsoils (20 – 100 cm) during the monitoring period (1995 – 1997). The EC values of the study soils were usually more than 20 dS/m. The instability of soil hydrology during the spring and summer resulted in larger variations in the field monitoring data. However, the Chuwei mangrove soils can be reliably classified as Halic Endoaquents or Halic Fluvaquents based on *Keys to Soil Taxonomy* (Soil Survey Staff, 1998).

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監測台灣北部紅樹林土壤氧化還原電位、pH 值及導電度之變化

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摘　要

本研究選擇台灣北部淡水河口之竹圍紅樹林沼澤地，兩年期（1995 年10 月至1997 年9 月）監測土壤氧化還原電位（Eh）、比導電度（EC）與pH 值，探討其土壤性質，並了解其土壤分類地位。結果顯示，由於紅樹林土壤受海水影響，pH 值趨於中性，有機物含量也比溫帶地區之濕地土壤含量為低。土壤之鹽基飽和度方面，因為交換性鈉含量偏高之故，而幾乎達100%。此土壤生態系中水溶液中之陽離子含量多寡之順序為：$Na^{+} > Mg^{2+} > K^{+} = Ca^{2+}$，而陰離子含量多寡之順序為：$Cl^{-} > SO_4^{2-} > NO_3^{-} > PO_4^{3-}$。縱使紅樹林中季節性的泛濫而使水文情況有所差異，但土壤終年都是處於極還原狀態（100 mV 至−200 mV）。表土（0 – 20 公分）Eh 值的空間與時間變異範圍比底土（20 – 100 公分）大。土壤在100 公分內的比導電度值都在20 dS/m 以上。竹圍紅樹林沼澤土壤可建議分類為鹽性型全層浸水新成土（Halic Endoaquents）或鹽性型沖積浸水新成土（Halic Fluvaquents）。