THE COMPOSITION OF MEKONG RIVER SILT AND ITS POSSIBLE ROLE AS A SOURCE OF PLANT NUTRIENT IN THE DELTA

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN SOIL SCIENCE

MAY 1974

By

Melvin Sanji Nishina

Thesis Committee:

Rollin C. Jones, Chairman
Tung Ming Lai
Gordon Y. Tsuji

ACKNOWLEDGEMENT

The authors wish to express their appreciation for the financial and logistical support provided by the United Nations Economic Commission for Asia and the Far East, (ECAFE), Committee for Coordination of Investigations of the Lower Mekong Basin; The Regional Economic Development Office, United States Embassy, Bangkok, Thailand; the Department of State, Agency for International Development, Washington, D. C.; Cantho University, Cantho, Viet Nam; and the numerous Agencies of the Government of South Viet Nam.

We are also indebted to Mr. J. Karl Lee, Water Resources Advisor, RED/Bangkok; Mr. Louis A. Cohen, Senior Engineering Advisor, and Mr. Surin Sangsnit of the Engineering Division, ECAFE/Bangkok for their assistance in coordination of the project in Viet Nam and Thailand; to Mr. Clayton C. Ingerson and Dr. Sidney A. Bowers, Agricultural Advisors, Cantho; Mr. Ralph W. Clark and Mr. J. B. Davis of USAID/ADFA Saigon; Mr. Khien of DIRE, My Tho; Mr. Tien of DIRE, Long Xuyen; Mr. Vu Ngoc Can of DIRE, Saigon; and Mr. Gary L. Nelson of the American Embassy, Saigon, Viet Nam; for their assistance in the collection of sediment samples from the Mekong River and soil samples from the Mekong Delta; to Mr. Ernest N. Okazaki, Mr. Roger T. Watanabe, and Dr. Rollin C. Jones of the Department of Agronomy and Soil Science, University of Hawaii, Honolulu, Hawaii for their assistance in the chemical and mineralogical analyses of both soil and sediment samples. Without their help, successful completion of this project would not have been possible.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Contd.)

ABSTRACT

It is alleged that the flood waters which annually innundate most of the Mekong Delta add nutrient-rich sediment to Delta soils. To test the validity of this allegation, the mineralogical and chemical composition of Mekong River sediment as well as soils of the Mekong Delta of Viet Nam was examined to establish the relationship between sediment deposition and soil fertility.

River sediment was collected at regular intervals from October 1972 to May 1973 at Long Xuyen, Cantho, and My Tho in South Viet Nam. Soils were collected along transects running perpendicular to the river at locations near the sediment sampling sites.

Small but significant differences in mineral, chemical, and acid extractable nutrient content were measured between sediment and soil. The sediment samples were higher in mica, hematite, kaolinite, feldspar, and chlorite-montmorillonite and lower in quartz contents. The sediment samples were also higher in magnesium, phosphorus, potassium, calcium, and manganese and lower in aluminum contents. The readily extractable phosphorus, potassium, and calcium content were also higher in the sediment than in soil samples.

Based on these data, the quantity of phosphorus, potassium magnesium and calcium added to a soil each year by sediment was computed. A one millimeter thick deposit of one g/cm^3 bulk density was assumed. The readily soluble nutrient added to a one Hectare area as measured by mild acid extraction amounted to 1.0 kologram P, 3.2 kilogram K, 4 kilogram Mg, and 50 kologram Ca per hectare. It was concluded that even if these computed values were doubled, the sediment deposit could not significantly increase the fertility of Delta soils.

Careful examination of the soil data confirmed the above conclusion. Soil data was examined on the assumption that soils which occur near the river bank would receive a larger quantity of sediment and therefore would contain a higher soluble nutrient content than soils which occur some distance from the river. The soil data did not bear this out.

Soil texture and soil moisture release data also did not vary with distance from the river channel.

Based on mineralogical, chemical, and physical analyses of sediments and soils of the Delta, it was concluded that the annual deposition of sediment does not measurably increase the fertility of Mekong Delta soils.

LIST OF FIGURES

LIST OF TABLES

Page

APPENDIX

LIST OF TABLES (Contd.)

INTRODUCTION

Harnessing of the Mekong River for power, flood control, irrigation, and navigation has been repeatedly cited as the single most crucial undertaking which can bring economic prosperity to the riparian states. The immense calculated benefits are, however, somewhat diminished, when several anticipated undesirable side effects related to upstream dam construction are taken into account. The alleged side effects range from problems in public health to destruction of aquatic life.

The task of identifying damaging side effects of a development project is no less important than publicizing the desirable ones. In the final analysis the net benefit derived from the Mekong River project will be the difference between the desirable and undesirable effects.

For example, while there is general agreement that water control is essential for increasing agricultural productivity in the Mekong delta, there are those who charge that upstream storage of water will reduce silt deposition of delta soils. The underlying assumption of this charge is that silt deposition is essential for the maintenance of soil fertility, and therefore, the survival of agriculture in the delta.

The purpose of this study is to develop and test a plan to examine the validity of this allegation.

RATIONALE AND OBJECTIVES

Nitrogen, phosphorus, and potassium are the three nutrient elements which are required in large quantities by crops. Nitrogen levels in delta soils are maintained through rainfall, symbiotic and non-symbiotic nitrogen fixing microorganisms and decomposition of organic matter.

Calcium, magnesium, and sulfur are also essential nutrient elements which are found in relatively high concentrations in plant tissue. Sulfur is probably not limiting in delta soils, and occurs in excess in the acid sulfate soils. Dissolved calcium and magnesium in the river water may be important in controlling the spread of acid sulfate soils, but transport of dissolved matter is not expected to be altered by the construction of dams.

Essential nutrient elements which occur in trace amounts in plant tissue are copper, zinc, iron, manganese, boron, and molybdenum. Chlorine, sodium, and silicon are not required for plant growth, but add to the well being of plants.

If the suspended solids in the water of the Mekong River serve to enrich the soil of the delta, they probably do so by adding phosphorus and potassium bearing minerals to the soil. Calcium and magnesium are two other elements which require scrutinity. Elements which are required in trace amounts by plants seldom become limiting until the major nutrients are first satisfied. This study will not attempt to examine trace elements in any detail.

Identification of essential plant nutrients in river sediment is not in itself positive indication of the value of the slit deposit to agriculture. Before addition of a particular element can benefit the land, that element must be deficient in the soil. For example, addition of sulfur to soils that are already well supplied with sulfur will probably have no beneficial effect and may in fact be detrimental to plant growth. Boron, manganese, iron, copper, zinc, or molybdenum can be toxic to plants in high concentrations. Sodium and chlorine are probably never in short supply on the delta and are known to occur in excess in salt affected area.

Apart from the deposition of silt, the annual floods are important in controlling chemical reactions in the soils of the delta. According to Bardach (1968) nutrients are converted to soluble forms through soil exposure during the dry season, and when the land is flooded the water becomes a "veritable nutrient broth" for fish. He presents no data or references to verify this statement.

Soil scientists have known for a long time that during the dry season, sulfur is converted to sulfuric acid. This results in extremely acid soils (Moorman, 1963; Pons and Kevie, 1969). The strong acid attacks the soil minerals and releases aluminum which is toxic to plants. When the delta is submerged under water, both from bank overflow and rain, sulfate-sulfur is reduced to sulfide-sulfur and the delta is again rendered productive. The cyclic change in soil acidity is most pronounced in acid-sulfate soils of the delta. Pons and Kevie (1969) suggest that for similar soils in Thailand a second crop of flooded rice is one way of using these soils during the dry season.

There is in addition a purely physical effect of sediment deposition on the delta. The narrow strips of levee soils are better drained and occupy higher elevation than land some distance from the river channels. These are the most intensively cultivated soils of the delta. While the nutritional value of the freshly deposited silt can be replaced by chemical fertilizers, it may not be possible to replace the geologic value of silt, However, the Mekong Delta is a region of crustal depression and this area continues to sink as the load of sediment accumulates, (Development and Resources Corporation, Working Paper MD-6, 1968),

The importance of the annual deposition of silt on the Delta must be determined so that sound decisions regarding future development of the Mekong River basin can be made, With this in mind, this study focused on three objectives, They were:

1. To determine the mineral and chemical composition of Mekong River sediment.
2. To measure physical, chemical, and mineral characteristic of selected Delta Soils, and
3. To establish the relationship between the mineral and chemical composition of river sediment to the agricultural productivity of Delta Soils.

REVIEW OF LITERATURE

The water of the Mekong River threads its way some 4200 kilometers from the Ribet Plateau to the warm tropical waters of the South China Sea. It is the 11th longest river, has the 8th largest average annual discharge, and has the 22nd largest drainage basin in the world (Ven Te Chow, 1964). At the proposed Pa Mong dam site, just west of Vientiane, Laos, the total sediment load of the Mekong River has been estimated to be 160 million metric tons per year (Pa Mong Phase II, Appendix III, 1972). Its average sediment concentration is about 1000 ppm (0.10%) and ranks 13th among the largest sediment carrying rivers on the world. This concentration is about double that of the Mississippi, one third that of the Rio Grande and Missouri, and one tenth that of the Colorado (Pa Mong Phase II, Appendix III, 1972).

According to the authors of the Pa Mong Phase II (1972 Appendix III, ppVii-26), when the Pa Mong dam is constructed, 99 percent of the sediment load will be trapped in the reservoir behind the dam. The clear water released downstream will replenish its depleted sediment load by scour and degradation of the downstream stream bed.

It is not clear how construction of upstream dams will alter the sediment load in the channels on the Delta, but it is certain that the river water, downstream from the dam site, will recover a portion of its former load. Unless the tributaries of the Mekong River, above and below the damsite contribute sediment of a different mineral composition, one can expect the mineral composition of the sediment load in the Delta to remain unchanged in the drainage basin below the damsite. Since a substantial portion of the discharge of the Mekong River at Phnom Penh enters the river from tributaries below the damsite, a damsite as far north as Pa Mong will most likely not substantially alter the quantity and quality of the sediment load in the Delta.

Other related side effects of a change on the mineral composition of the silt or a reduced silt load have been cited by Kassas (1971). In an article on the Nile River ecological system, Kassas (1971) states that "the reduction of the Nile's annual flood-load of sediments that the natural river system brought to its delta shores, is causing serious marine erosion and alarming retreat of the delta shore-line". He also cites fishery losses in the eastern Mediterranean due to changes in the silt load. Bardach (1971) noting the relationship between the construction of the Aswan High Dam and the decline of fisheries in the eastern Mediterranean emphatically states that main-stream dams on the Mekong would similarly deplete the estuarine and offshore fisheries of Southern South Vietnam.

Abrupt changes in the quality and quantity of the river sediment, and changes in the flooding patterns on the delta may, as some believe, affect agriculture and aquaculture in unexpected ways. Whether these changes will in fact occur is still a matter of debate. Those concerned with this problem should keep close watch of the events that occur on the Nile, but at the same time should avoid making direct extrapolation of Nile experiences to the Mekong. A careful analysis of the situation in the drainage basin of the Mekong will add invaluable insight for predicting the ultimate changes which will take place.

MATERIALS AND METHOD

Collection of Suspended Solids in Mekong River Water

River water samples were collected periodically from three locations in the Delta.

All sampling sites on the Delta are identified on the map in Figure 1 and sampling dates are provided in Table 1.

Twenty liters of river water were collected from mid-stream at prescribed time intervals. After collection, sufficient sedimentation time was allowed for a particle 0.2 microns in diameter to settle the full length of the container, after which the supernatant liquid was siphoned off. The remaining slurry was thoroughly air-dried and quantitatively transferred to a small plastic vial for shipment to Honolulu.

Upon receipt of the samples, they were placed in weighing bottles and oven-dried. The oven-dried mass and water content was recorded. The samples were crushed in an agate mortar and powdered to pass a 100 mesh screen before they were subjected to powder x-ray diffraction analysis.

Collection of Soils from the Mekong Delta

Forty-five samples from fourteen profiles were collected from three areas of the Delta from March 22-27, 1973. The three areas included transects running perpendicular to the Bassac and Mekong Rivers at Long Xuyen, Cantho, and My Tho as indicated in Figure 1. Sampling sites for each profile was established by soil maps provided in working paper MD-6 (1968) entitled Mekong Delta Development Program

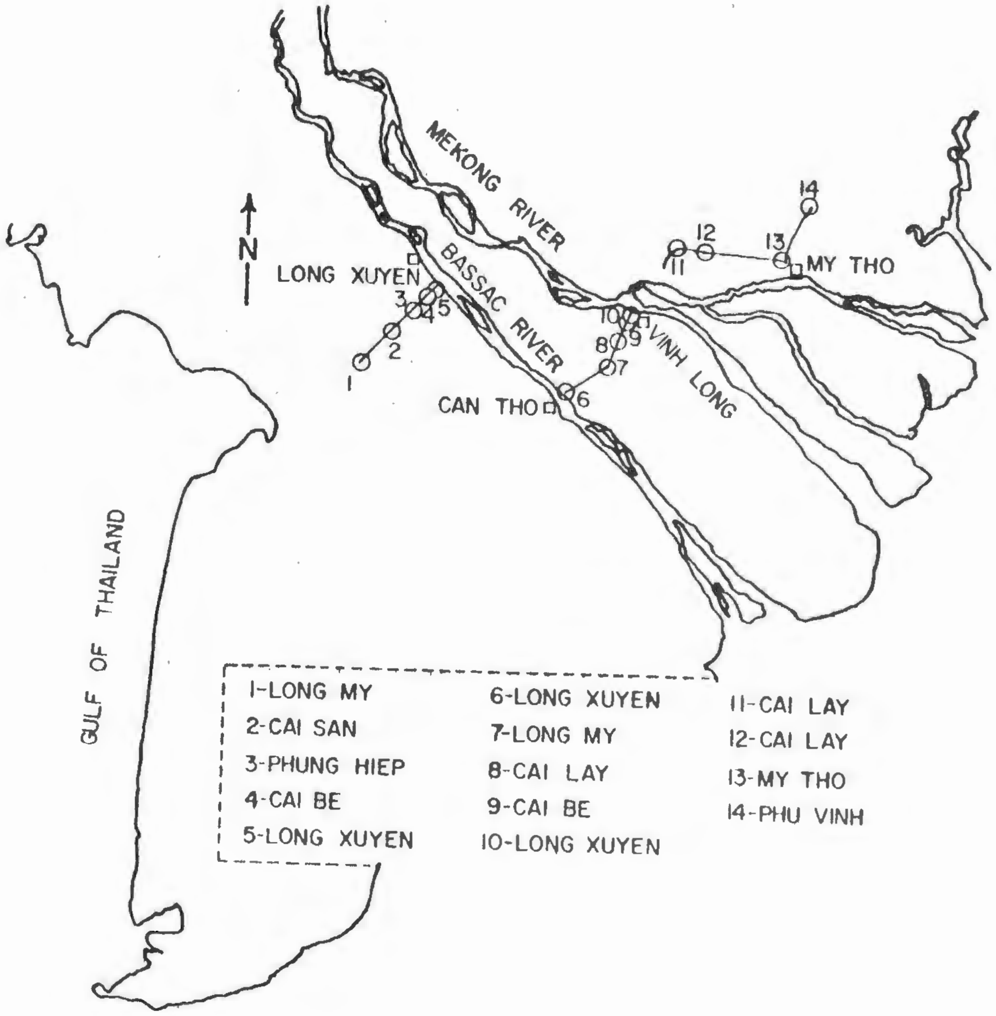

Figure 1. Soil Sampling Sites of Transects Running Perpendicular to the Bassac and Mekong Rivers on the Delta.

Table 1. Sampling Dates of Sediment Collection from Long Xuyen, Cantho, My Tho, Bien Hoa, Binh Loi, Viet Nam; Phnom Pehn, Cambodia; Vietiane, Laos; and Mukdahan, Thailand

Location	Date Collected	Symbol
Long Xuyen	10-23-72	L_1
	10-30-72	L_2
	11-06-72*	L_3
	11-06-72*	L_4
	11-13-72	L_5
	11-20-72	L_6
	1-20-73	L_7
	2-20-73	L_8
	3-20-73	L_9
	4-20-73	L_{10}
	5-20-73	L_{11}
	6-21-73	L_{12}
	7-20-73	L_{13}
	8-21-73	L_{14}
	9-20-73	L_{15}
	10-20-73	L_{16}
Cantho	10-18-72	C_1
	10-27-72	C_2
	10-31-72	C_3
	11-07-72	C_4
	11-14-72	C_5
	11-21-72	C_6
	1-20-73	C_7
	2-20-73	C_8
	3-20-73	C_9
	9-18-73	C_{10}
	10-15-73	C_{11}
My Tho	10-24-72	M_1
	10-31-72	M_2
	11-07-72	M_3
	11-14-72	M_4
	11-21-72	M_5
	11-28-72	M_6
	1-26-73	M_7
	2-26-73	M_8
	3-27-73	M_9
	4-27-73	M_{10}
	5-26-73	M_{11}
	6-26-73	M_{12}
	7-26-73	M_{13}

Table 1. (Continued) Sampling Dates of Sediment Collection from Long Xuyen, Cantho, My Tho, Bien Hoa, Binh Loi, Viet Nam; Phnom Pehn, Cambodia; Vietiane, Laos; and Mukdahan, Thailand

Location	Date Collected	Symbol
Bien Hoa Water Supply	9-04-73	BH_1
	9-21-73	BH_2
	10-22-73	BH_3
Binh Loi Bridge	8-15-73	BL_1
	9-04-73	BL_2
	9-21-73	BL_3
	10-22-73	BL_4
Phnom Pehn	9-10-73	P_1
	9-20-73	P_2
Vietiane	8-30-73	V_1
	no date	V_2
Mukdahan	9-10-73	MK_1
	9-20-73	MK_2
	10-10-73	MK_3
	11-09-73	MK_4

*Samples received with identical sampling dates.

prepared by the Development and Resources Corporation for USAID. Considering the reconnaissance nature of the soil map, the correspondence between anticipated and observed soil was satisfactory. The Cai Be series collected from the University of Cantho campus was also analyzed.

All soil samples were collected in duplicate. One set was sent to the Soils and Water Laboratory of the Department of Land Development, Bangkok, and the other to the University of Hawaii. The Bangkok samples were subjected to measurements of mechanical analysis, hydraulic conductivity, moisture release, soil pH, organic carbon, available phosphorus, active iron, saturation extract, exchangeable aluminum, titratable acidity, cation exchange capacity, base saturation, exchange acidity, and extractable bases. Those brought to Hawaii were subjected to mineralogical analysis by x-ray diffraction, total chemical analysis by x-ray fluorescence, and exchangeable nutrient content by Rapid Chemical Method (RCM).

Ten soil profiles were selected for core sampling. These cores were subjected to moisture release, bulk density, and hydraulic conductivity analysis. Upon completion of physical analyses, the cores were dried, pulverized, and analyzed for mineral composition by x-ray diffraction.

Quantitative Mineral Analysis By X-Ray Diffraction

Standard minerals, soil and sediment samples were air-dried and pulverized to pass through a 100 mesh screen. Randomly oriented powdered samples were then placed on a glass slide with an aluminum holder and mounted a Norelco X-ray diffractometer.

The X-ray unit with a copper tube was set at 50 kilovolts and 25 milliamps. The diffracted radiation was received through a curved crystal graphite focusing monochronometer and detected by a scintillation counter attached to a pulse height analyzer. The instrument settings for all standards and unknowns were, time constant 4, scale factor 2, and multiplier 1, with the source slit $\frac{1}{2}^{\circ}$ and anti-scatter slit 1° for the first 14°. From 14° to 64°, the instrument settings were changed to scale factor 4, source slit 1° and anti-scatter slit 4° with the other settings remaining the same.

Eight minerals were identified in the solids collected from the Mekong River. These minerals were kaolinite, quartz, hematite, feldspar, rutile, mica, chlorite, and montmorillonite. Not only did these minerals occur in all samples but their concentrations in the solid fraction were remarkably uniform.

In order to convert x-ray diffraction line intensity to mineral concentrations, mixtures containing all eight minerals were prepared. The relative proportions of minerals in the mixtures are provided in Table 2.

X-ray diffraction patterns of these mixtures were obtained and intensity was measured for appropriate peaks. A planimeter was used to measure the area under the peak to obtain a quantitative and reproducible value for line intensity. Table 3 shows the hkl reflection used for each mineral.

The weight percentage X of a particular mineral species is related to one of its line intensity I_x by the relation:

$$X = \frac{A_x\ I_x}{A_s\ I_s}$$

Table 2. Weight Percentages of Standard Minerals.
M=14 Angstrom Minerals (Montmorillonite + Chlorite), I=Mica, K=Kaolinite, R=Rutile, F=Feldspar, H=Hematite, Q=Quartz

No.	M	I	K	R	F	H	Q
1	24.0	26.0	5.0	10.0	15.0	10.0	10.0
2	12.0	20.0	30.0	1.0	6.0	1.0	30.0
3	12.0	10.0	25.0	2.0	8.0	3.0	40.0
4	10.0	14.0	20.0	0.5	4.0	1.5	50.0
5	6.0	12.0	15.0	2.5	2.0	2.5	60.0
6	2.0	4.0	10.0	4.0	5.0	5.0	70.0
7	22.5	6.0	10.0	14.0	8.0	5.0	34.5
8	21.0	18.0	8.0	12.0	10.0	6.0	25.0
9	19.5	22.0	6.0	10.0	14.0	7.0	21.5
10	18.0	30.0	4.0	8.0	16.0	8.0	16.0
11	10.5	34.0	2.0	6.0	18.0	12.0	17.5
12	14.0	16.0	20.0	5.0	10.0	5.0	30.0
13	18.0	10.0	25.0	5.0	12.0	5.0	25.0
14	10.0	10.0	30.0	8.0	5.0	7.0	30.0
15	17.0	15.0	10.0	10.0	8.0	5.0	35.0
16	20.0	8.0	15.0	5.0	7.0	5.0	40.0
17	31.0	25.0	19.0	3.0	1.0	16.0	5.0
18	30.5	36.0	14.0	3.5	3.0	6.0	7.0
19	31.0	28.0	17.0	4.5	3.0	14.0	2.5
20	29.0	40.0	13.0	5.5	4.0	4.5	4.0
21	28.0	24.0	21.0	6.5	13.0	4.0	3.5

Table 2. (Continued) Weight Percentages of Standard Minerals. M=14 Angstrom Minerals (Montmorillonite + Chlorite), I=Mica, K=Kaolinite, R=Rutile, F=Feldspar, H=Hematite, Q-Quartz

No.	M	I	K	R	F	H	Q
22	38.0	23.0	23.0	7.5	7.0	4.0	7.5
23	29.0	21.0	26.0	8.5	9.0	3.5	3.0
24	30.0	19.0	28.0	9.0	11.0	2.0	1.0
25	31.0	17.0	35.0	9.5	6.0	0.5	1.0

Table 3. hKl Lines Used for Computing Mineral Percentages

Mineral*	d-spacing (Angstroms)	Relative Intensity	hKl
14 Angstrom Minerals (Chlorite-Chester, Vermont) (Montmorillonite, Santa, Rita, New Mexico)	14.10-14.73	100	001
Mica (Biotite-Bancroft, Ontario) (Muscovite Taos, New Mexico)	10.00	100	002
Kaolinite (Lamar Pit, Bath, South Carolina)	7.16	100	001
Rutile (Kragero, Norway)	3.24	100	110
Feldspar (Essex County, New York)	3.18	100	022,040
Hematite (Ward's Natural Science Establishment, Inc. Rochester, New York)	2.69	100	104
Quartz (Hot Springs, Arkansas)	1.81	17	112

* All minerals from Ward's Natural Science Establishment, Inc.

where A_x is the mass absorption coefficient of the specimen, I_s is the diffraction line intensity on a standard mineral for which S is known, and A_s is the mass adsorption coefficient of the standard mixture. It is clear from this relation that a plot of X versus I_x will be linear only when A_s is equal to A_x. Since that possibility is unlikely, some have attempted to measure A_s and A_x, but this is not always possible.

In order to account for differences in mass adsorption coefficient among samples, an empirical approach was taken in this study. The weight percentage was related not only to the line intensity of the mineral in question but to all other minerals through the following multiple correlation equation.

$$X = a_0 + I_x(a_1 + a_2I_y + a_3I_z + ...) \qquad (1)$$

where I_x is the intensity of the mineral in question and I_y, I_z, ... are intensities of the other minerals in the specimen, and a_0, a_1, a_2, a_3, ... are linear correlation coefficients.

Since the line intensity for a particular mineral depends not only on the concentrations of that particular mineral but on the concentration and composition of other minerals in the samples as well, one should expect a strong dependence of the line intensity of the mineral in question to the line intensity of the other minerals in the sample. According to equation 1 the predicted quantity of a mineral species is related to the line intensity of the mineral in question as well as the product of all other minerals and the mineral in question.

Appendix A shows how each additional variable contributes to the improvement of R^2 values for predicting quantitative mineral analysis.

Quantitative mineral analysis was accomplished by solving equation 1 after inserting the appropriate line intensities (peak areas) into the equation.

Total Chemical Analysis

Selected sediment and soil samples were subjected to total chemical analysis by x-ray fluorescence spectroscopy. The method suggested by Andermann (1961) was utilized with modifications.

The flux (lithium tetraborate) to sample ratio was changed from 1:1 to 2:1. Fusion of the sample was carried out at 950°C for 30 minutes rather than the 2500°F (1371°C) for 1½ minutes used by Andermann. To insure uniformity of particle size, each sample was ground in a Spex grinder for 25 minutes rather than 1½ minutes. Finally, boric acid instead of cellulose powder was used as the sample backing for pressing the sample into a pellet.

Standards and samples were prepared in identical manner and analyzed by an ARL Model 72000 X-Ray Fluorescence Quantometer. The relationship of intensity reading in volts and percent element was obtained as in the x-ray diffraction analysis. Multiple regression equations were calculated and used to convert voltage reading to percent elemental oxides for the samples.

Moisture Release, Bulk Density, and Hydraulic Conductivity Measurements

Moisture release measurements up to suctions of one bar were made on soil cores by use of Tempe pressure cells (Catalog No. 1400, Soilmoisture Equipment Company). The method utilized was essentially that of Reginato and van Bavel (1962). Water content-suction data beyond one bar were measured by the Bangkok laboratory (see Tables 15-18).

Upon completion of the moisture release measurements, the core was oven-dried and weighed in order to compute both soil water content at the final suction (1 bar) and soil bulk density.

Hydraulic conductivity was computed from the measured water release curves by a method proposed by Kunze et al (1968).

Available Soil Nutrients

A Rapid Chemical Method (RCM) developed by Spurway and Lawton (1949) was used to measure readily available nutrients in soil and sediment samples. It involves extraction of nutrients by a weak acid and the subsequent measurement of these nutrients. The concentration of the available nutrients is determined by comparing either the turbidity or developed color with standard blocks.

The quantity of material required (0.5 - 0.7 gm) for this analysis was quite large and necessitated combining several sediment samples.

Bangkok Data

Samples sent to the Soils and Water Laboratory of the Department of Land Cooperatives, Bangkok, were analyzed according to the methods described in a manual prepared by the Bureau of Reclamation, United States Department of Interior. The manual is entitled "Laboratory Procedures" and that portion utilized was part-517 of series 510.

RESULTS AND DISCUSSION

Sediment Concentration

The basic theory governing sediment motion has been summarized by Einstein (1964). According to Einstein, between 80 to 90 percent of the sediment load is wash load, or that portion which the flow can easily carry in large quantities and is generally limited by its availability in the watershed. Einstein goes on to state that since wash load is the finer part of the load, it should not only be expected to be predominately in suspension, but also to be evenly distributed over the entire cross section.

In 1960 and 1961, the Harza Engineering Company was employed to collect hydrologic data, and established many suspended sampling stations along the Mekong. The Harza report was not available for examination, but a summary of the Harza data has been compiled by the Naval Oceanographic Office, Washington, D.C.[1/] A plot of sediment concentration and discharge as a function of time is reproduced from the summary report of the Naval Oceanographic Office in Figure 2.

At Chau Doc in 1961, the sediment concentration ranged from a low of about 20 to 40 ppm between January to May, to a high of about 500 ppm in late August, some six weeks before peak discharge. Since the water picks up more loose material at the beginning of the monsoon, the sediment concentration, peaks before discharge.

Sediment concentration for other sites are provided in Table 4.

[1/] This report was kindly supplied by Dr. Herman Huizig, ECAFE, Bangkok.

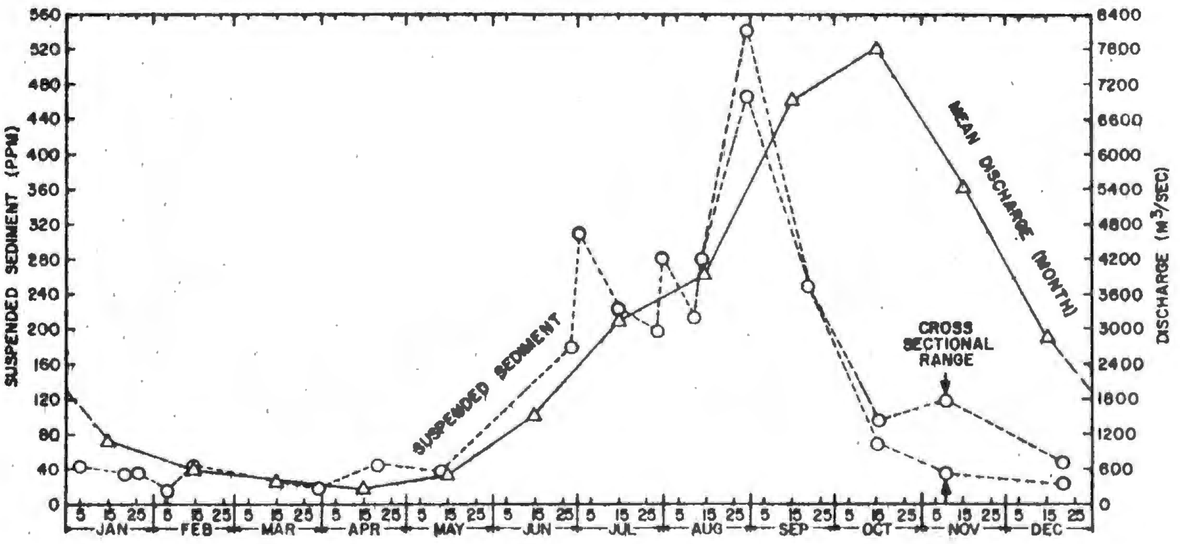

Figure 2. Suspended Sediment Concentration and Monthly Discharge Curves. Figure reproduced from Summary of Harza Report by Naval Oceanographic Office.

Table 4A. The Average Sediment Concentration Per Month in PPM*

Station	Month											
	Jan.		Feb.		Mar.		Apr.		May		June	
	ave.	no.	ave.	no.	ave.	no.	ave.	no.	ave.	no.	ave.	no.
KRATIE	--	-	--	-	--	-	--	-	--	-	--	-
KG CHAM	--	-	--	-	--	-	--	-	--	-	--	-
PHNOM PENH	11	2	11	2	--	-	--	-	12	1	291	4
PREK KDAM	56	4	34	4	35	3	38	3	49	4	125	11
(DEBIT SOLIDE) 1962	--	-	--	-	--	-	--	-	--	-	--	-
g/m^3 1963	53	1	29	2	30	2	38	3	50	2	110	8
KAS THOM	--	-	--	-	--	-	--	-	--	-	--	-
PREK DACH	--	-	--	-	--	-	--	-	--	-	--	-
TON CHAU	--	-	--	-	--	-	--	-	--	-	--	-
VINH LONG	106	1	--	-	--	-	--	-	--	-	--	-
MY THUAN	--	-	--	-	--	-	--	-	--	-	--	-
MY THO	106	1	--	-	--	-	--	-	--	-	--	-
CHAU DOC	38	3	31	2	18	1	45	1	36	1	178	1
LONG XUYEN	89	1	--	-	--	-	--	-	--	-	--	-
VAM CONG	--	-	--	-	--	-	--	-	--	-	--	-
BON TONG CANAL	--	-	--	-	286	2	--	-	--	-	--	-
at Long Xuyen River												
at Thanh Quoi Project												
RACH SOI DI VAM CONG	--	-	--	-	151	1	140	1	--	-	--	-
High Tide : Low Tide												
CLOSE TO CANAL LAGRANGE	--	-	--	-	--	-	--	-	--	-	--	-
(Muoi Hai and Phu Sun)												

*includes organic matter in suspension. Data supplied by Dr. Herman Huizig, ECAFE, Bangkok.

Table 4B. The Average Sediment Concentration Per Month in PPM*

Station		Month											
		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.	
		ave.	no.	ave.	no.	ave.	no.	ave.	no.	ave.	no.	ave.	no.
KRATIE		--	-	266	2	179	1	165	2	66	2	72	1
KG CHAM		190	1	284	2	320	2	164	2	88	2	110	1
PHNOM PENH		337	6	450	7	366	11	283	11	79	6	54	4
PREK KDAM		134	20	210	21	75	12	108	10	76	3	74	3
(DEBIT SOLIDE)	1962	--	1	93	2	103	2	43	4	73	2	59	2
g/m^3	1963	116	14	200	14	69	6	18	1	--	-	--	-
KAS THOM		294	1	393	2	266	2	160	2	74	2	31	1
PREK DACH		388	1	634	2	323	2	--	-	--	-	--	-
TON CHAU		--	-	--	-	--	-	--	-	--	-	46	2
VINH LONG		--	-	--	-	--	-	--	-	--	-	59	1
MY THUAN		--	-	--	-	--	-	420	2	127	3	41	2
MY THO		--	-	--	-	--	-	--	-	--	-	91	1
CHAU DOC		251	4	374	4	248	1	85	3	76	2	40	4
LONG XUYEN		--	-	--	-	--	-	--	-	--	-	34	1
VAM CONG		--	-	--	-	--	-	347	2	170	2	127	2
BON TONG CANAL		--	-	--	-	--	-	--	-	--	-	--	-
at Long Xuyen River													
at Thanh Quoi Project													
RACH SOI DI VAM CONG		--	-	--	-	--	-	--	-	--	-	--	-
High Tide : Low Tide													
CLOSE TO CANAL LAGRANGE		--	-	--	-	278	1	--	-	--	-	--	-

*includes organic matter in suspension.

The data include those collected by the French in 1906, 1911, 1940, and 1944/45 as well as Harza data. When the differences in location, year and sampling procedures are considered, the differences within a given month do not seem large, and the peak concentration about August is consistent with the result in Figure 2.

Size distribution as a function of concentration or time of year was not available and no information on the mineral composition of sediments could be found at the time of the preparation of this report. Between October 1972 to October 1973, suspended sediment was collected at approximately two weeks intervals at Long Xuyen, Cantho and My Tho in South Viet Nam. The sediment concentration in ppm is plotted as a function of time of year for the period between October 1972 to October 1973. (Figure 3) Based on the Harza experience (Figure 2) the October high from 1972 at Long Xuyen, Cantho and My Tho must be assumed to represent the declining tail of the concentration-time relations for suspended sediment in the Mekong and Bassac Rivers.

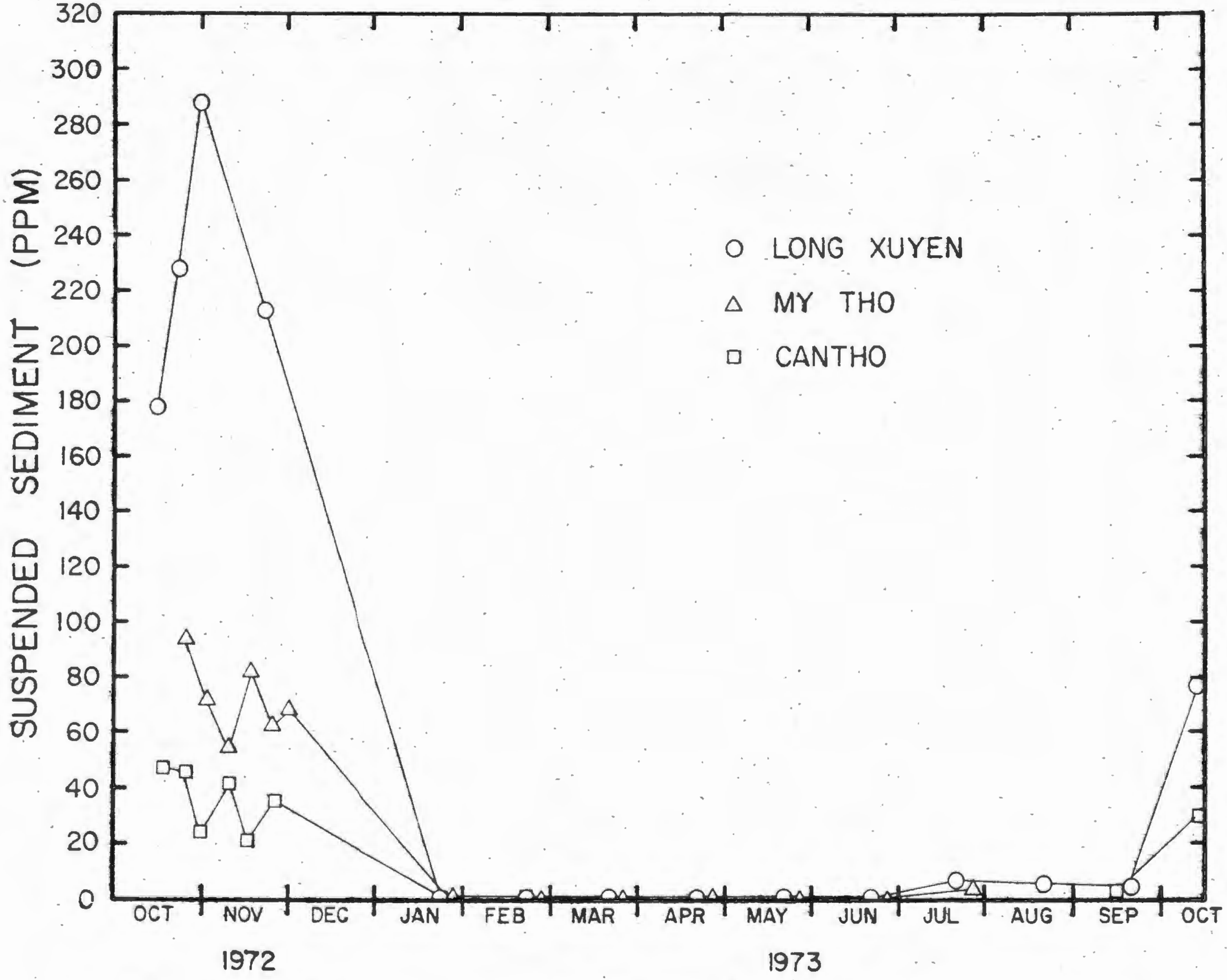

Figure 3. Suspended Sediment Concentration Curves for Long Xuyen, Cantho, and My Tho.

MINERALOGICAL ANALYSIS

Sediments

The mineral composition of Mekong River sediment is remarkably uniform and does not change with collection site or time of collection. Minerals identified in the sediment by x-ray diffraction analysis were mica, quartz, kaolinite, feldspar, hematite, chlorite, montmorillonite, and rutile. Idealized chemical formulae for these minerals are presented in Table 5.

Data on the mineral composition of sediment (percent) collected from October 18, 1972 to October 20, 1973 at Long Xuyen, Cantho, and My Tho, Vietnam, Phonm Pehn, Cambodia and Vientiane, Laos are presented in Tables 6, 7, 8, and 9, and the means and standard deviations for each mineral are summarized in Table 10.

The minerals identified in the sediment can be grouped into three categories on the basis of their resistance to weathering. Plagioclase feldspar which is an easily weatherable mineral, falls in the first category. The second group consists of mica, chlorite, and montmorillonite, which are moderately stable minerals. The last group consisting of kaolinite, quartz, hematite, and rutile are considered very stable and therefore would accumulate in the soil at the expense of the less stable and more weatherable minerals. For example, the following equations from Garrels and Christ (1965) describe the weathering of mica or plagioclase feldspar to kaolinite,

$$\underset{\text{(mica)}}{2KAlSi_3O_{10}(OH)_2} + 2H^+ + 3H_2O = \underset{\text{(kaolinite)}}{Al_2Si_2O_5(OH)_4} + 2K^+$$

and

Table 5. Idealized Mineral Formula

Mineral Name	Formula
14 Angstrom Minerals (Chlorite)	$Al_4(Mg,Fe)_{10}Si_6O_{20}(OH)_{16}$
(Montmorillonite)	$(Al,Mg)_4Si_8O_{20}(OH)_4$
Mica	$K(Si_7Al_1)Al_4O_{20}(OH)_4$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Rutile	TiO_2
Feldspar (albite)	$(Na)AlSi_3O_8$
Hematite	Fe_2O_3
Quartz	SiO_2

Table 6. X-Ray Analysis of River Sediment and Soil Collected Near Long Xuyen. M = Montmorillonite + Chlorite, I = Mica, K = Kaolinite, R = Rutile, F = Feldspar, H = Hematite, Q = Quartz

Mineral Composition in Percent

Sediment

Collection Date	M	I	K	R	F	H	Q
10-23-72	9.3	57	13	0.5	7.0	1.8	11
10-30-72	8.2	56	13	0.5	6.0	1.6	15
11-06-72*	8.4	50	13	0.3	5.6	1.5	21
11-06-72*	7.4	57	13	0.6	6.5	1.7	14
11-13-72	6.5	57	14	0.6	6.9	1.8	13
11-20-72	7.6	49	14	0.6	6.0	1.7	21
2-20-73	5.7	54	14	0.6	7.7	2.0	16
3-20-73	6.3	53	13	0.5	7.9	2.0	16
4-20-73	5.8	49	14	0.6	6.1	1.7	23
5-20-73	6.1	53	14	0.6	5.9	1.7	19
6-21-73	6.4	51	15	0.6	6.1	1.8	19
7-20-73	7.7	56	15	0.6	5.8	1.7	14
8-21-73	8.0	47	15	0.7	6.3	1.8	21
9-20-73	8.1	49	15	0.6	6.1	1.8	20
10-15-73	7.4	52	15	0.6	5.8	1.6	17

Soil

Soil Name	Depth (cm)	M	I	K	R	F	H	Q
Long My	(0-10)	7.9	33	15	0.7	5.9	1.8	36
	(10-25)	7.9	34	15	0.7	6.0	1.8	35
	(25-43)	6.8	35	15	0.7	6.0	1.8	35
Cai San	(0-15)	7.8	32	17	0.7	6.4	2.0	34
	(15-30)	8.0	36	15	0.7	6.0	1.9	32
	(30-53)	7.1	35	16	0.7	6.3	1.9	34
Phung Hiep	(0-10)	8.0	25	16	0.7	6.6	2.0	42
	(10-20)	8.2	24	17	0.8	6.6	2.0	41
	(20-38)	8.0	34	15	0.7	6.0	1.8	35
	(38-61)	7.6	41	14	0.6	5.8	1.7	29
Cai Be	(0-10)	8.6	26	18	0.8	7.2	2.2	37
	(10-28)	9.7	30	16	0.7	6.2	2.0	35
	(28-36)	9.7	28	17	0.8	6.7	2.1	36
	(36-64)	6.4	43	14	0.6	5.9	1.7	28
Long Xuyen	(0-10)	7.6	46	14	0.6	6.0	1.7	25
	(15-28)	7.6	50	14	0.6	7.2	1.8	20
	(28-46)	7.7	43	14	0.6	6.0	1.7	28

*Samples received with identical sampling dates.

Table 7. X-Ray Analysis of River Sediment and Soil Collected Near Cantho. M = Montmorillonite + Chlorite, I = Mica, K = Kaolinite, R = Rutile, F = Feldspar, H = Hematite, Q = Quartz

Mineral Composition in Percent

Sediment

Collection Date	M	I	K	R	F	H	Q
10-18-72	7.5	43	16	0.7	6.4	1.9	24
10-27-72	7.2	50	16	0.7	6.5	1.8	18
10-31-72	7.8	39	18	0.8	6.9	2.0	25
11-07-72	6.6	47	15	0.6	6.1	1.7	23
11-14-72	7.9	41	17	0.8	6.8	2.0	25
11-21-72	7.0	47	15	0.7	6.1	1.8	23
1-20-73	7.3	58	14	0.6	5.7	1.6	13
2-20-73	7.6	38	17	0.7	6.3	1.8	30
3-20-73	7.0	43	14	0.6	6.0	1.7	28
9-18-73	7.7	49	15	0.7	6.0	1.7	19
10-20-73	6.0	54	14	0.6	6.5	1.8	17

Soil

Soil Name	Depth (cm)	M	I	K	R	F	H	Q
Long Xuyen	(0-15)	6.9	43	14	0.6	5.9	1.7	28
	(15-41)	6.4	34	14	0.6	5.5	1.6	38
	(41-51)	7.7	37	14	0.6	5.8	1.6	33
Cai Be	(0-28)	7.1	35	16	0.7	6.3	1.9	34
	(28-41)	8.4	34	15	0.7	6.2	1.8	34
Cai Lay	(0-15)	6.5	38	15	0.7	6.0	1.8	33
	(15-28)	5.4	41	14	0.6	5.9	1.7	31
	(28-51)	5.6	43	13	0.6	5.7	1.6	30
Long My	(0-10)	6.8	38	13	0.6	5.5	1.6	34
	(10-25)	7.1	20	14	0.6	5.9	1.8	51
	(25-41)	5.6	31	14	0.6	6.1	1.7	41
	(41-50)	6.5	36	14	0.6	5.7	1.7	36
Long Xuyen	(0-15)	6.9	37	13	0.6	5.9	1.6	35
	(15-30)	6.2	28	14	0.6	5.9	1.7	43
	(30-48)	6.8	34	15	0.7	5.8	1.7	36

Table 8. X-Ray Analysis of River Sediment and Soil Collected Near My Tho. M = Montmorillonite + Chlorite, I = Mica, K = Kaolinite, R = Rutile, F = Feldspar, H = Hematite, Q = Quartz

Mineral Composition in Percent

Sediment

Collection Date	M	I	K	R	F	H	Q
10-24-72	6.3	52	15	0,7	5,8	1,7	18
10-31-72	7,8	40	16	0,7	6.3	1.8	28
11-07-72	7,4	45	16	0.7	6,4	1,8	23
11-14-72	7.0	47	15	0.6	6,2	1,7	22
11-21-72	7.3	41	16	0,7	6.5	1.8	26
11-28-72	7.1	43	15	0.7	6.4	1.8	25
1-26-73	6,7	41	15	0.6	7.7	2.1	27
2-26-73	6.1	29	15	0,6	6.2	1,8	42
3-27-73	7,0	41	17	0.7	6,6	2,0	26
4-27-73	6.8	38	17	0.8	6,9	2.1	28
5-26-73	7,9	38	17	0,8	6,9	2,0	27
6-26-73	8,6	29	19	0,8	7.5	2,3	33
7-26-73	8,1	48	15	0,7	6,2	1,8	19

Soil

Soil Name	Depth (cm)	M	I	K	R	F	H	Q
Cai Lay	(0-18)	6.9	31	17	0,7	6.5	1,9	36
	(18-36)	6,8	35	16	0,7	6,9	1.9	34
	(36-53)	8.0	25	14	0.6	5.9	1,7	44
Cai Lay	(0-18)	3.3	5.9	8,2	0.4	3.3	1,0	78
	(18-33)	2.3	4,4	5.2	0.3	2,2	0.7	85
	(33-56)	3.6	7.2	7.0	0,3	3,4	1.0	78
My Tho	(0-20)	3.8	5,2	8.4	0.4	3.4	0,7	78
	(20-46)	3.6	7,1	7.5	0.5	3,4	1.0	77
Phu Vinh	(0-18)	5.6	49	15	0.6	5,9	1,7	23
	(18-41)	5.6	41	15	0.6	6,1	1.8	30
	(41-53)	6,9	12	17	0,8	6,9	1.9	54
	(53-76)	2.9	5.8	7,4	0,4	3.0	0.7	80
	(76-107)	2,6	8,1	6,7	0.3	3.0	0,8	78

Table 9. X-Ray Analysis of River Sediment Collected Near Phnom Phen, Cambodia; Vietiane, Laos; Bien Hoa Water Supply and Binh Loi Bridge, Viet Nam; and Mukdahan, Thailand

Mineral Composition in Percent

Sediment

Location	Date	M	I	K	R	F	H	Q
Phnom Pehn	9-10-73	7.8	53	14	0.6	5.6	1.6	17
Phnom Pehn	9-20-73	7.3	50	15	0.6	6.1	1.7	20
Vietiane	8-30-73	6.0	48	14	0.6	6.7	1.8	23
Vietiane	(no date)	8.5	51	14	0.5	5.9	1.6	19
Bien Hoa Water Supply	9-04-73	6.9	15	19	0.8	7.3	2.0	48
	9-21-73	9.5	25	24	1.0	9.0	2.5	29
	10-22-73	6.5	29	16	0.7	6.1	1.7	40
Binh Loi Bridge	8-15-73	6.6	29	16	0.7	5.9	1.8	39
	9-04-73	7.5	26	18	0.8	6.7	1.9	39
	9-21-73	8.2	22	19	0.8	7.0	2.1	41
	10-22-73	6.7	22	17	0.7	6.4	1.9	46
Mukdahan	9-10-73	7.9	64	13	0.4	5.8	1.6	70
	9-20-73	7.4	58	13	0.6	6.8	1.7	12
	10-10-73	7.0	59	14	0.6	6.1	1.7	12
	11-09-73	8.7	47	14	0.6	6.0	1.7	21

Table 10. Statistical Analysis of Mineral Composition

	M	I	K	R	F	H	Q
All Soil							
Mean	6.59*	30.24**	13.74*	0.62	5.66*	1.65*	41.64**
Std. Dev.	1.78	12.65	3.10	0.13	1.19	0.38	17.41
Top Soil							
Mean	6.69	31.72**	14.26	0.63	5.77	1.69	39.50**
Std. Dev.	1.53	13.00	2.92	0.11	1.11	0.40	17.03
Sediment							
Mean	7.28	46.62	15.14	0.65	6.25	1.82	22.03
Std. Dev.	0.81	7.41	1.46	0.10	0.57	0.16	6.27

* Significantly different from sediment samples at the 5% level.

** Significantly different from sediment samples at the 1% level.

$$2(Na)AlSi_3O_8 + 2H^+ + 9H_2O = Al_2Si_2O_5(OH)_4 + 2Na^+ + 4H_4SiO_4$$

(feldspar) (kaolinite)

The first equation illustrates a weathering process which results in release of K^+ and the second equation illustrates weathering of feldspar to give Na^+. If K^+ or Na^+ is limiting in the Delta, deposition and subsequent weathering of minerals such as mica and feldspar would serve to enrich the soils.

Soils

Mineralogical data for selected Delta Soils are presented in Tables 6, 7, and 8 and statistical data are summarized in Table 10. The X-Ray diffraction patterns of soil samples were nearly identical to the patterns for sediments (see Figure 4). Only after careful analysis of the data was it possible to show differences in mineral composition between soil and sediment.

The statistical analysis shows that stable and moderately stable minerals such as quartz, occur in significantly higher quantities in the soil than in the sediment. This suggests that minerals such as mica, kaolinite, hematite, feldspar, and chlorite-montmorillonite which occur in significantly higher amounts in the river sediments than in the soils decompose when they are deposited on Delta soils.

TOTAL CHEMICAL ANALYSIS

Small but significant differences are noted between the elemental composition of sediment and soils (see Tables 11, 12, 13 and 14). MgO, P_2O_5, K_2O, CaO, and MnO, are lower and Al_2O_3 is higher in the soil than in the sediment. The results confirm the well established weathering principle that soluble elements such as potassium, magnesium,

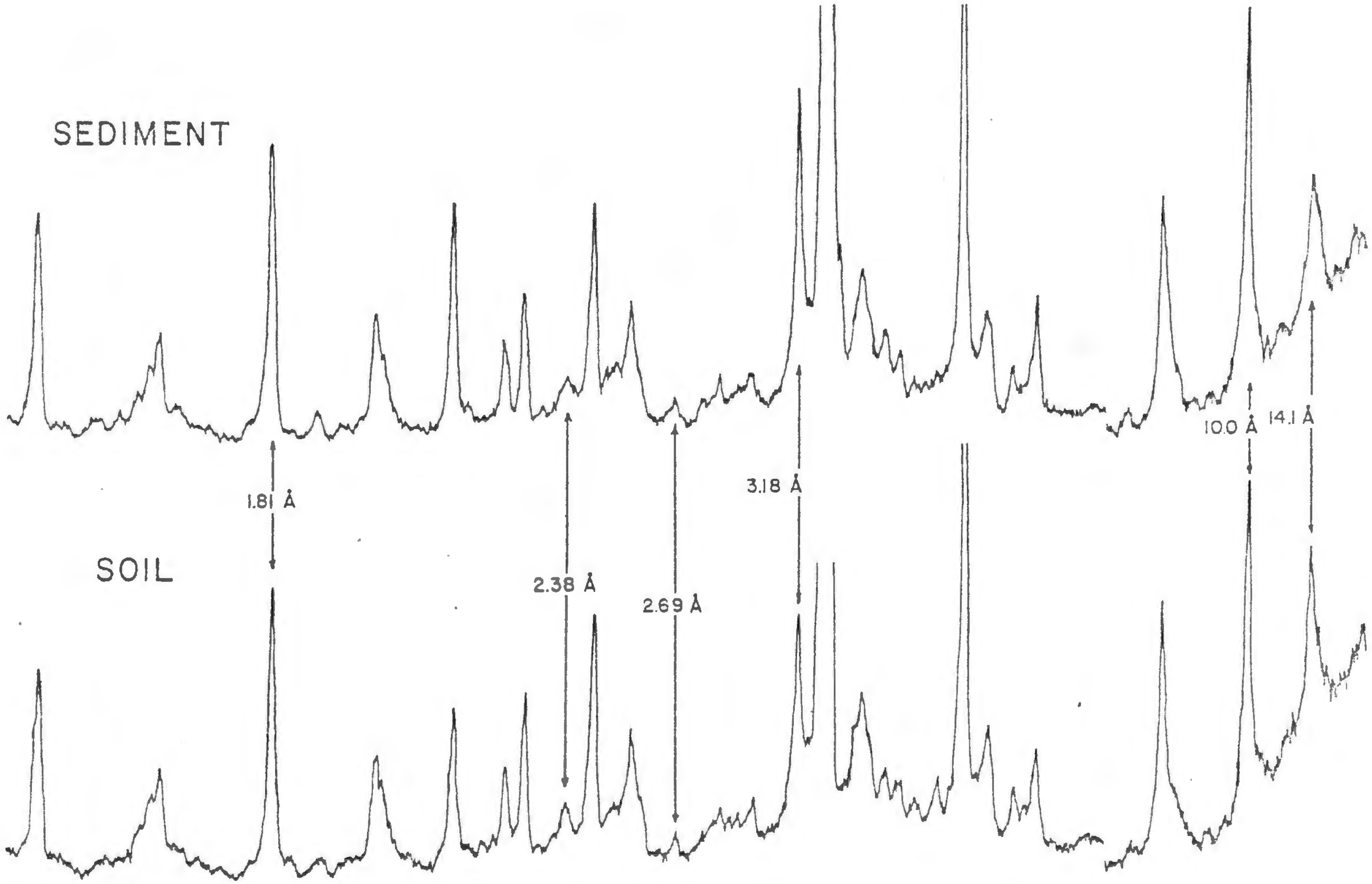

Figure 4. X-ray Diffraction Patterns of Sediment and Soil Samples.

Table 11. Chemical Composition in Percent of Soil and Sediment from Long Xuyen

Sediment

Collection Date	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI*
11-06-72	4.41	1.60	8.93	73.05	0.16	3.16	0.57	0.99	0.07	3.18	3.87
11-20-72	3.40	1.63	11.67	69.40	0.09	3.13	0.43	1.05	0.05	4.61	4.55

Soil

Soil Name	depth (cm)	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI
LONG MY	(0-10)	3.11	1.06	14.70	63.75	0.07	3.50	0.14	0.85	0.05	2.14	10.64
	(10-25)	3.36	1.03	15.16	63.03	0.07	3.56	0.11	0.86	0.04	2.06	10.72
	(25-43)	2.30	1.02	17.92	62.59	0.08	3.06	0.05	0.92	0.03	4.89	7.14
CAI SAN	(0-15)	3.10	0.97	18.12	58.34	0.07	3.95	0.16	0.71	0.04	3.47	11.06
	(15-30)	2.55	1.09	17.43	62.27	0.07	3.75	0.08	0.84	0.02	5.00	6.89
PHUNG HIEP	(0-10)	2.14	0.90	18.88	59.48	0.07	3.14	0.26	0.76	0.03	3.38	10.95
	(10-20)	2.50	0.90	17.83	59.48	0.07	3.15	0.27	0.73	0.03	4.10	10.46
CAI BE	(0-10)	2.45	0.90	17.82	59.08	0.07	3.15	0.35	0.86	0.03	3.63	11.68
	(10-28)	2.88	1.05	17.39	61.18	0.07	3.25	0.32	0.93	0.03	2.61	10.29
LONG XUYEN	(0-15)	3.16	1.28	11.29	71.07	0.07	2.71	0.26	1.14	0.03	4.47	4.52
	(15-28)	3.15	1.30	11.41	71.16	0.07	2.85	0.21	1.17	0.03	4.45	4.21

*LOI = Loss on Ignition

Table 12. Chemical Composition in Percent of Soil and Sediment from Cantho

Sediment

Collection Date	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI*
10-27-72	2.00	1.67	16.19	58.18	0.10	4.03	0.60	0.79	0.10	6.90	9.45
11-07-72	3.27	1.83	12.51	61.94	0.11	4.26	0.68	0.84	0.14	5.15	9.27

Soil

Soil Name	depth (cm)	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI
LONG XUYEN	(0-15)	2.30	1.29	16.93	62.77	0.07	3.45	0.29	1.02	0.04	5.30	6.53
	(15-41)	2.49	1.13	14.42	67.06	0.07	2.96	0.25	1.09	0.02	5.07	5.45
CAI LAY	(0-15)	1.96	0.85	17.11	57.65	0.07	3.33	0.08	0.94	0.03	6.46	11.52
	(15-28)	2.65	0.98	18.44	61.44	0.07	3.73	0.24	0.98	0.02	5.31	6.13
LONG XUYEN	(0-15)	2.33	1.11	17.87	59.48	0.07	3.72	0.11	0.96	0.03	8.73	5.60
	(15-30)	3.83	1.10	17.18	65.84	0.08	3.75	0.12	1.12	0.02	0.45	6.51

*LOI = Loss on Ignition

Table 13. Chemical Composition in Percent of Soil and Sediment from My Tho

Sediment

Collection Date	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI*
10-24-72	1.43	1.75	17.30	55.00	0.08	4.21	0.57	0.78	0.09	7.61	11.19
10-31-72	2.58	1.83	14.56	60.73	0.08	4.58	0.59	0.79	0.11	6.39	7.76

Soil

Soil Name	depth (cm)	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI
CAI LAY	(0-18)	2.40	0.98	18.28	59.58	0.08	3.49	0.32	0.93	0.03	5.82	8.11
	(18-33)	2.87	1.18	15.45	64.09	0.07	3.38	0.27	1.07	0.02	4.41	7.19
CAI LAY	(0-18)	3.38	0.88	14.33	75.14	0.08	2.64	0.54	1.31	0.02	0.42	0.80
	(18-35)	3.80	0.82	13.62	75.75	0.08	2.65	0.36	1.31	0.02	0.79	0.82
MY THO	(0-20)	3.41	0.73	14.57	69.68	0.08	2.99	0.12	1.27	0.02	0.93	6.21
	(20-46)	2.95	0.74	17.87	65.60	0.08	2.86	0.37	1.06	0.02	1.62	6.82
PHU VINH	(0-18)	2.15	1.10	18.22	65.12	0.08	3.21	0.38	1.15	0.02	7.65	0.90
	(18-41)	2.79	1.04	18.94	66.59	0.08	3.65	0.45	1.01	0.02	4.37	1.06

*LOI = Loss on Ignition

Table 14. Statistical Analysis for Total Chemical Analysis

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	Fe_2O_3	LOI
ALL SOILS											
MEAN	2.82	1.02**	16.45*	64.29	0.07**	3.27**	0.24**	1.00	0.03**	3.90	6.89
STD. DEV.	0.54	0.16	2.20	5.07	0.01	0.38	0.13	0.17	0.01	2.17	3.50
TOP SOILS											
MEAN	2.70	1.00**	16.51*	63.43	0.07**	3.27*	0.25**	0.99	0.03**	4.37	7.38
STD. DEV.	0.60	0.17	2.28	5.47	0.01	0.38	0.14	0.19	0.01	2.56	3.95
SEDIMENT											
MEAN	2.85	1.72	13.53	63.05	0.10	3.90	0.57	0.87	0.09	5.64	7.68
STD. DEV.	1.07	0.10	3.10	6.86	0.03	0.61	0.08	0.12	0.03	1.64	2.91

*Significantly different from silt samples at the 5% level.
**Significantly different from silt samples at the 1% level.

and calcium are leached and insoluble oxides such as Al_2O_3 accumulate in soils. Manganese is an exception. This element generally accumulates under well drained conditions, but in the delta, it is rendered soluble under acid and reducing conditions and lost through leaching. In the Phu Vinh series for example, manganese nodules were clearly visible in the subsoil, but rarely occurred near the surface.

When the comparison in chemical composition is restricted to sediment versus top soil, the results remain unchanged.

ACID EXTRACTABLE NUTRIENTS

A total elemental analysis is not a sensitive index of the quantity of readily available nutrient in soils or sediment. A mild extractant such as a dilute acid which removes only a small fraction of the total quantity of each element is a better measure of the readily available nutrients. Table 15 shows a comparison of the amount of K, Mg, Ca, and P extracted by mild acid (0.3 NHCl) from top soil and river sediment. There was an insufficient quantity of sediment to subject each sample to the latter analysis, and even for the acid extraction, the analysis is, in some cases, of composite samples.

A cursory examination of the data Table 15 shows that, with the possible exception of magnesium, there is more acid extractable calcium, phosphorus, and potassium in the sediment than in the top soil. On the basis of this information one can state without hesitation that the sediment is richer in readily available calcium, potassium, and phosphorus than Delta Soils.

It should follow from the above that soils receiving the largest quantity of sediment each year should also be the richest in these

Table 15. Rapid Chemical Analysis of Available Nutrients (Kg/Ha) in Soil and Sediment Samples

Sediment

	P	K	Ca	Mg
Long Xuyen*				
L_1	75	320	5000	350
L_2	75	320	4000	350
L_3	100	320	4000	350
L_4	100	160	4000	350
L_4+L_5	75	320	5000	350
L_6	75	160	2000	250
$L_7+L_8+L_9+L_{10}+L_{11}$	75	320	6000	350
Cantho*				
$C_1+C_3+C_5+C_6$	50	240	5000	250
$C_7+C_8+C_9$	75	240	4000	350
My Tho*				
M_3+M_5	50	240	3000	250
$M_6+M_7+M_8$	75	320	5000	350

Soil

Soil	depth (cm)	P	K	Ca	Mg
Long Xuyen Transect					
Long My	(0-10)	35	80	1000	350
Cai San	(0-15)	25	120	1000	500
Phung Hiep	(0-15)	25	160	2000	500
Cai Be	(0-10)	TR**	240	2000	250
Long Xuyen	(0-15)	25	120	1000	250
Cantho Transect					
Long Xuyen	(0-15)	25	80	1000	250
Cai Be	(0-28)	TR	160	2000	250
Cai Lay	(0-15)	TR	240	2000	350
Long My	(0-10)	25	160	4000	250
Long Xuyen	(0-15)	TR	160	2000	500
My Tho Transect					
Cai Lay	(0-18)	TR	80	1000	750
Cai Lay	(0-18)	25	40	500	250
My Tho	(0-20)	TR	160	2000	750
Phu Vinh	(0-18)	75	60	500	250

*Code for L_1, L_2 etc. found in Table I, page 9.

**TR = trace

elements. A careful examination of the data in Table 15 shows that this is not so. The Long Xuyen series, for example, which occurs near the river bank is no richer in these nutrients than other soils located many kilometers from the river.

This apparent discrepancy can be readily explained. If one assumes that the bulk density of deposited sediment is one gm/cm^3, and further that the sediment deposited each year is one millimeter thick, then the total mass of sediment deposited in one hectare would be 10 metric tons. Based on RCM data, ten tons of sediment containing 100 ppm P, 320 ppm K, 400 ppm Mg, and 5000 ppm Ca will add approximately, 1.0 kilogram of P, 3.2 kilogram K, 4 kilogram Mg, and 50 kilogram Ca to a hectare of soil. It should be pointed out however, that the nutrient content measured by RCM analysis does not reflect the available nutrient content as shown by chemical fertilizer analyses.

A soil of the same bulk density as the sediment and which has concentrations one-fourth as much of each element as the sediment, will contain 25 times more of each element in a 10 cm depth. For example a soil with 25 ppm P has 25 kilograms of P per hectare in a 10 cm depth.

The contribution of sediment to the fertility of Delta soils depends, therefore, not only on the nutrient content of the sediment but also on the quantity of sediment which is deposited each year. Even if the nutrient content of the sediment were doubled, the contribution of nutrients to the soil would be small, if only one millimeter of sediment were deposited each year.

An annual deposit of one millimeter would result in a one meter thick layer of sediment in a thousand years and differences in elevation of one meter between regions of deposition and non-deposition should develop. A cursory examination of the Delta topography suggests that an annual deposit of one millimeter is not unreasonable.

Based on the data one must conclude that although the sediment is richer in nutrients than the soils, the quantity of sediment deposited each year does not measurably increase the fertility of Delta Soils.

SEDIMENT DEPOSITION AND SOIL DISTRIBUTION PATTERNS

When a river overflows its banks, the coarsest suspended particles are deposited nearest the river channel and the finest particles are deposited furthest from the river channel. This pattern of sediment deposition can have an important effect on the texture and therefore the physical characteristics of soils. To measure differences in soil characteristics attributable to sediment deposition patterns, soils were collected wherever possible along transects which ran perpendicular to the main river channels. For example, five soils were collected along a 30 kilometer transect on highway LTL 8A running parallel to a canal south of the city of Long Xuyen. The soils collected along this transect in increasing proximity to the Bassac River were the Long My, Cai San, Phung Hiep, Cai Be, and Long Xuyen series. If one looks for textural differences among soils in this transect he finds that only the Long Xuyen series differ from the others (Appendic C, Tables C1, C2, C3, and C4). The clay content of the Long Xuyen soil is about one half that of the others. The Long Xuyen soil, while texturally different, occupies a small part of the Delta. The soil analysis shows that while textural differences do occur, these differences disappear within a kilometer or so from the river channel.

In the transect between the city of Cantho and Vinh Long along highway QLTH4, textural differences occur at random and appear to be unrelated to distance from the main channel.

This random pattern was also found in the My Tho transect. The Phu Vinh series, near the city of My Tho, derives its coarse texture from an ancient coastal dune.

In every soil which could be identified as developed directly from alluvium, over 90 percent of the particles by weight are less than 5 microns in diameter. Mechanical analyses of river sediment determined by the Harza Engineering Company (Naval Oceanographic Office Report, 1961) show that the sediment is coarser in texture than the soil. Even soils near the river banks (Long Xuyen series) is finer in texture than the river sediment.

About 4000 years ago, glacial melt raised the sea level, and the delta as we know it, was part of the South China Sea. (Development and Resources Corporation, Working Paper MD-6, 1968). The texture and mineral composition of the sediments, through deposition in a marine environment followed by the emergence of the Delta from the sea some two to three thousand years ago, determine to a large extent the present character of Delta soils. The heavy texture of Delta soils, the frequent occurrence of acid sulfate soils, and the extreme flatness and lowness of the Delta are a consequence of events which took place in geologic history.

Since the emergence of the Delta from the sea, the soils have matured. As soils age, they develop characteristics which are associated and controlled by environmental factors. In the delta the main factors are the monsoon climate, flooding, sea water intrusion, and subtle but important differences in elevation and therefore drainage.

The pronounced wet and dry monsoon climate controls oxygen levels in Delta soils. When the soils are flooded, reducing conditions prevail, soil pH rises and nutrients, particularly phosphorus, are released. The reverse process takes place when the soils dry out. The fluctuation in pH is most pronounced in acid sulfate soils. Two large areas in Vietnam, the Plain of Reeds and the north-western tip of south Vietnam bordered on the west by the Gulf of Thailand and to the east by the Seven Mountains are covered with acid sulfate soils. These areas do not receive sediment deposition,

The general soil map of Vietnam (Moorman, 1961) clearly shows that the intensity of acid sulfate conditions increase as one moves away from the main river channel of the Mekong. While the intensity of soil acidity is generally lower near the major river channels, this is true only for top soil. The Cai Be series collected to a depth of 180 cm on the campus of the Cantho University illustrates the extremely acid nature of the subsoil (Appendix C, Table C4), even for soils which occur near the river. It appears that over the past 2000 years, the river has played an important part in establishing the present distribution of acid sulfate soils in the Delta.

While careful analysis shows that there are small but significant differences in mineral, chemical and physical composition between soil and sediment, these differences do not diminish even for soils which occur relatively close to the river, The only exception to this is the Long Xuyen series collected near the city of Long Xuyen. Other Long Xuyen series collected south of Cantho are not as coarse textured as their counterpart to the north. This suggests that sediment deposition is greater in the northern sector of the Delta where depth of flooding is greater. However agricultural productivity does not appear to be greater on the area north of Long Xuyen relative to productivity near Cantho or My Tho. In fact the reverse may be the case.

It is true however that within a region, farming is more intense near the river bank than elsewhere. This appears to be related to the fact that the river levee occupies higher ground where water control is obtained with greater ease. In addition, close proximity to transportation encourages intensive cultivation near the river. Intensive farming near the river, associated with better water control and access to transportation and marketing has probably contributed to the feeling that soil fertility is related to annual silt deposition.

SOIL PHYSICAL PROPERTIES

The plant nutrient level in a soil is one of the most easily manipulated agronomic variable. A parcel of intensively cultivated land is soon depleted of one or two essential nutrients and it becomes necessary to add these deficient elements to the soil in the form of chemical fertilizers. Even now, before construction of upstream dams, high rice yields are not possible without application of nitrogen fertilizer.

The tall-strawed traditional rice variety's which have been selected to give low but dependable yields under adverse conditions are gradually being replaced by new short-strawed varieties. These new varieties require precise water control and respond dramatically to addition of nitrogen fertilizers. While nutrients from river sediment may have been adequate to sustain agriculture under the traditional farming system, a modern agricultural system can not depend on the river to supply the nutrient needs of the new high yielding varieties.

Soil fertility can be maintained by man. It is, as stated at the outset, one of the most readily controlled agronomic variable. If the nutrient value of sediment is not crucial to agriculture on the Delta, what about the geologic worth of sediment? Do the annual floods deposit silt which improves the physical condition of Delta Soils?

The answer to this question is contained in the moisture characteristic curves (Figures 5 to 6). The curves relate the soil water content (cm^3/cm^3) in a given value of soil as a function of soil water suction (cm). A soil with many large pores will release water even at low tensions. Such a soil is well drained and is generally considered to have good physical properties. A heavy soil, with many fine pores will retain water even at very high suctions. Such soils drain slowly and while generally not suited for growing most crops, are in fact, ideal for rice culture.

Figure 6 illustrates a moisture release curve of a soil with large pores (Molokai Soil) and in addition, curves for the Cai Be soils from the Delta. Soils which drain readily are those which are coarse textured (see Phu Vinh series, Appendix C, Table C3) of well aggregated heavy clay soils such as the Molokai soil whose water release curve is shown in Figure 6.

Hydraulic conductivity-water content relationships for Delta soils were computed from the water characteristic curves, using the procedure described by Kunze _et al_ (1968). The data is presented in Appendix E.

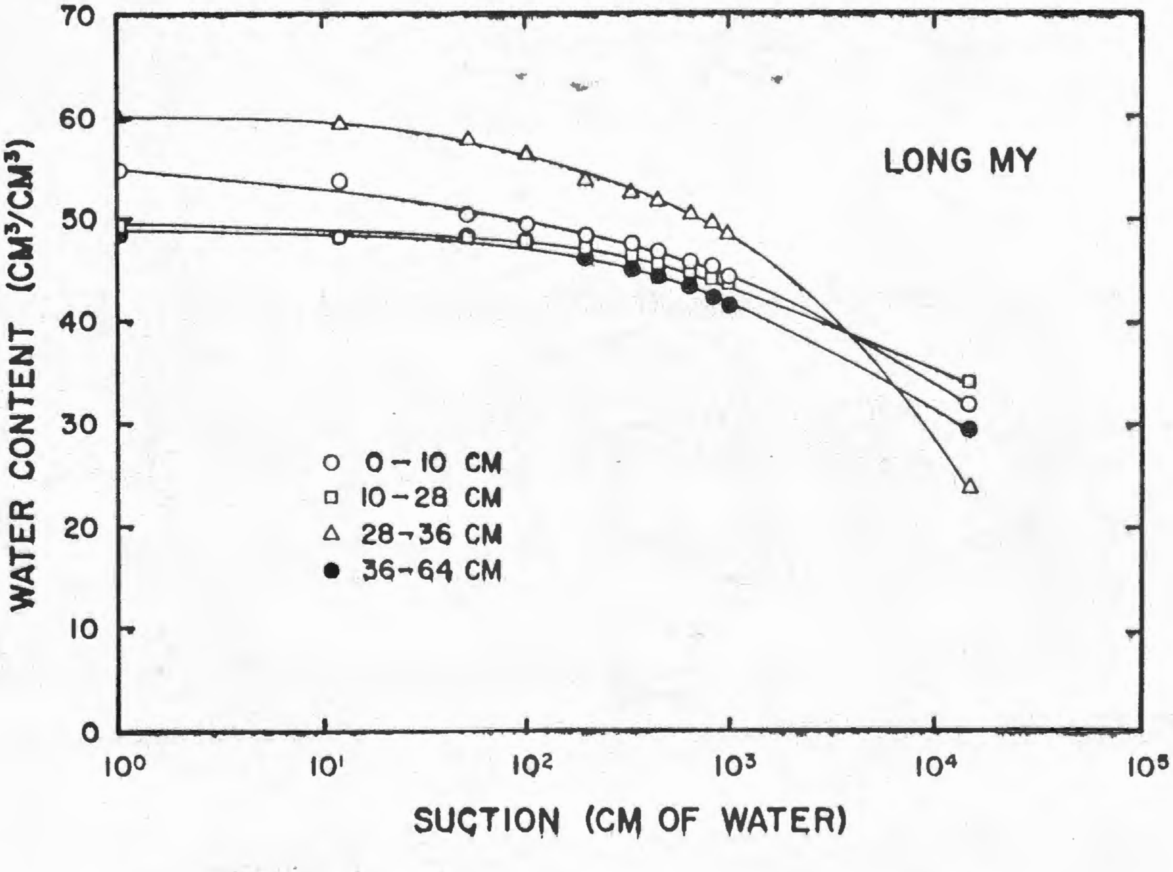

Figure 5. Moisture Characteristic Curve for Long My Soil.

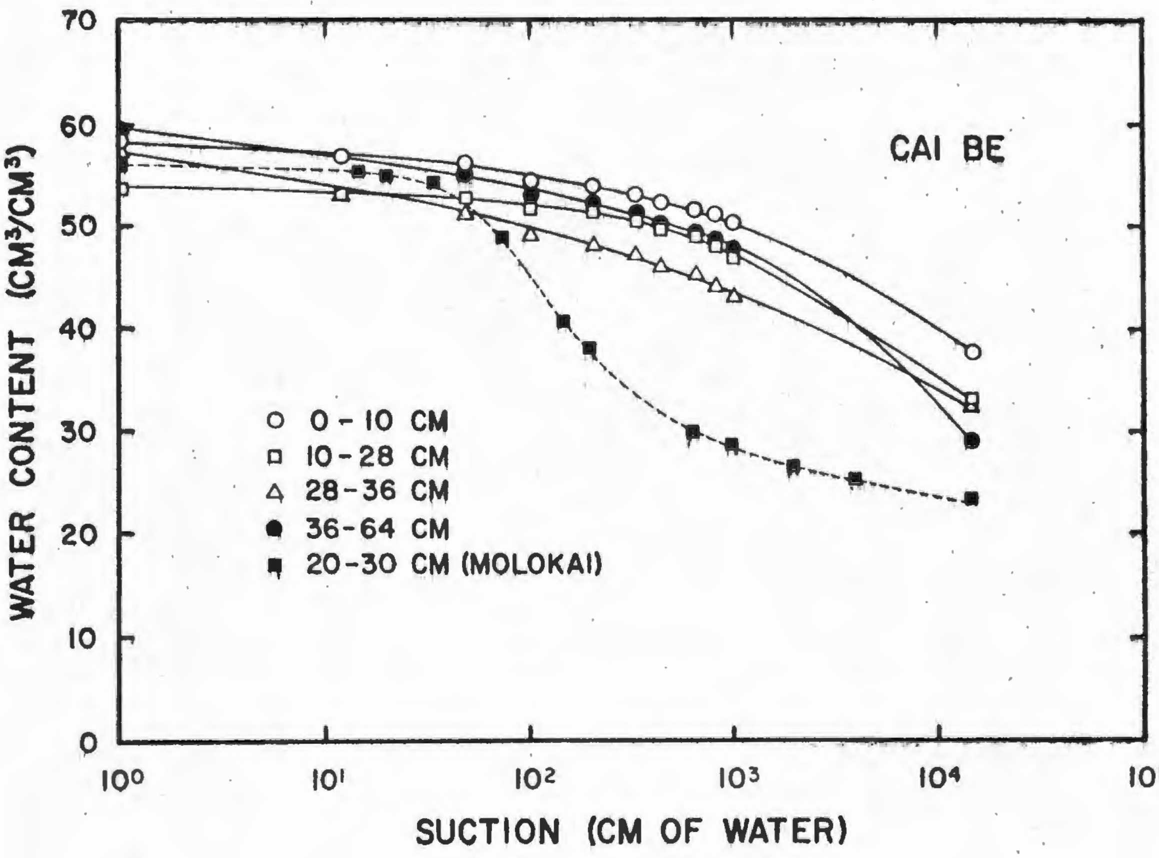

Figure 6. Moisture Characteristic Curve for Cai Be Soil. Molokai Soil Moisture Characteristic Curve from Tsuji (1967).

In Figures 7 and 8, the data for the Long My and Cai Be soils are presented graphically. The conductivity-water content relation of a well-aggregated soil (Molokai series) is included in Figure 8 for comparison.

In soils of the Delta, hydraulic conductivity drops off sharply with decreasing water content. Whether this rapid decrease is an artifact or not is debatable since calculation methods are empirical equations based on water release or pore size distribution curves of very porous materials. However, since water content in Delta soils does not change significantly with suction up to one bar, a small change in water content would have a marked effect on conductivity. This would be clearly evident if conductivity was plotted against suction. Conductivity would remain fairly high for a large range of suction, and would drop off sharply when water drains from the pores in substantial quantities. In well-aggregated soils, where calculation methods are applicable, the conductivity is higher at any water content because water is loosely held in large pores. Water in these pores drain easily at low suctions so that well-aggregated clay soils such as the Molokai behave like sands or gravels.

The soils of the Delta are predominately clay and silty clay soils. They are poorly aggregated, and release water very slowly as is evident from the flatness of the moisture characteristic curves between zero to one bar suction. Here again soil properties do not seem to change with distance from the river. One can therefore conclude that in the Delta of South Vietnam, the river has not measurably altered the physical properties of soil.

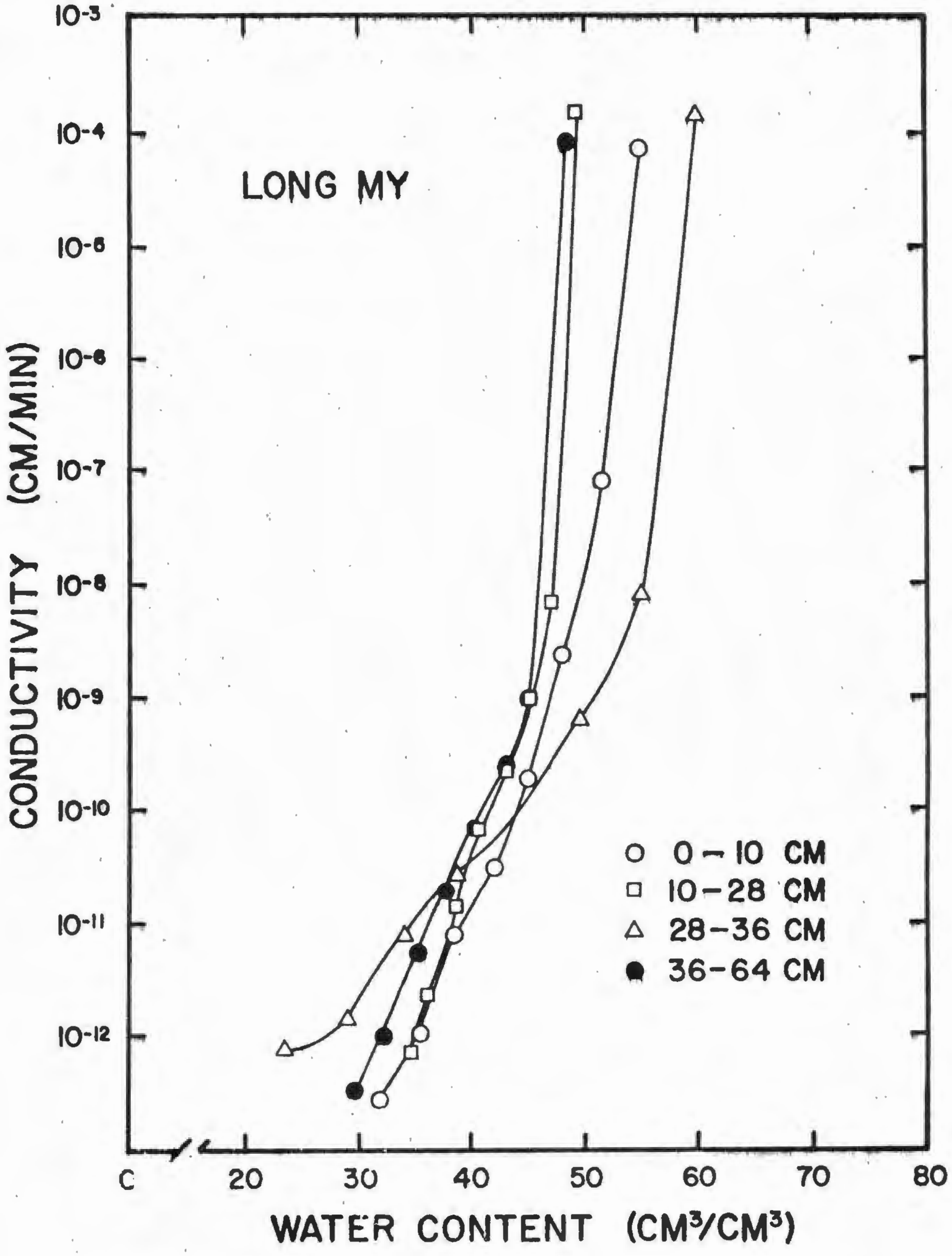

Figure 7, Hydraulic Conductivity Curves for Long My Soil,

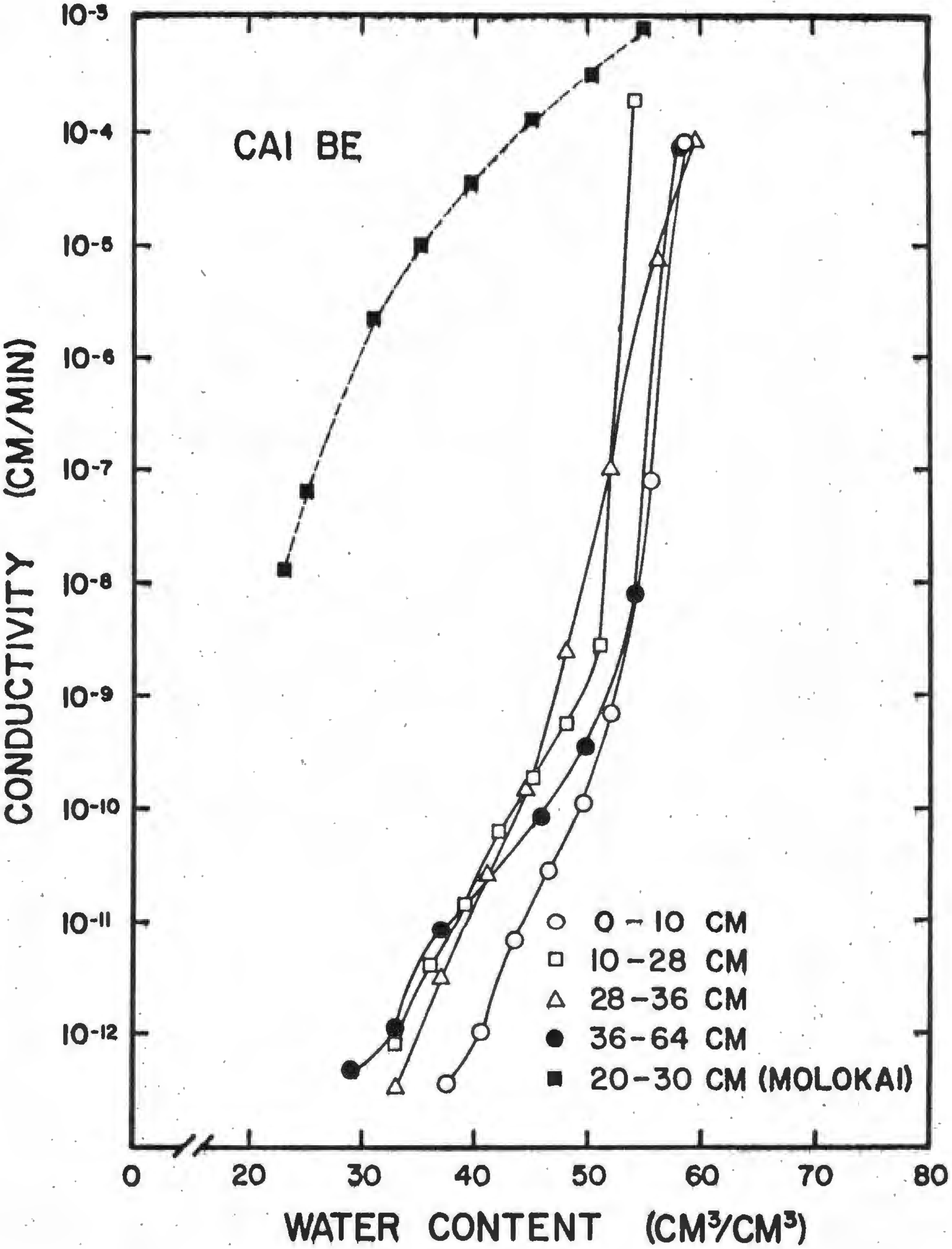

Figure 8. Hydraulic Conductivity Curves for Cai Be Soil. Molokai Soil Hydraulic Conductivity Curve from Harada (1970).

The poor physical condition of Delta soil is partly the result of puddling soils for rice culture. Some means to regenerate soil structure must be developed so that crops other than rice (eg. soybean, sorghum, corn) can be grown on Delta soil during the dry season. That regeneration of soil structure is not an impossible feat can be judged from the success of the farmers in growing vegetables, corn, and pulse crops on raised beds. The task for future workers is to do this on a large scale for production of export crops.

CONCLUSION

The findings of this study show that sediment deposition does not measurably increase the soil fertility of soil on the Mekong Delta. These findings apply to the study area and any attempt to extrapolate data to the northern sector of the Delta should be made with care.

In addition the relationship between sediment and fish production has not been considered.

If the role of sediment on agriculture is considered without consideration of other side effects, water control on the Delta is the single most important change that can bring about dramatic increase in the Delta's agricultural production. Without water control, proven agronomic practices which are essential for high crop yield will not be successful. In any case, elimination of silt deposition on Delta soils should no longer be a negative factor against dam construction on the Mekong River.

LITERATURE CITED

1. Andermann, G. 1961. Improvements in the X-Ray Emmission Analysis of Cement Raw Mix. Analytical Chemistry 33 : 1689-1695.

2. Bardach, J. E. 1968. Mainstream Dams and Commercial Fisheries of the Mekong. Asia 20 : 62-70.

3. Bardach, J. E. 1971. There is More to Dams than Meets the Eyes. Asia 20 : 9-13.

4. Bardach, J. E. 1959. Report on Fisheries in Cambodia. USOM/ Cambodia.

5. Bureau of Reclamation. 1956. Lower Mekong River Basin; A Reconnaissance Report Prepared for International Cooperation Administration. Washington.

6. Bureau of Reclamation. 1967. Laboratory Procedures, Part 517 of Series 510, Land Classification Techniques and Standards, Reclamation Instructions, U. S. Bureau of Reclamation, Denver, Colorado.

7. Chevey, P. 1934. The Great Lake of Cambodia: The Underlying Causes of its Richness in Fish. Proceedings of the 5th Pacific Science Congress 5 : 3809-3816.

8. Chow, V. T. 1964. Handbook of Applied Hydrology. McGraw-Hill Book Company, New York.

9. Department of the Army Engineer Agency for Resources Inventory. 1967. An Gaing Province, Vietnam Resources Inventory. Washington.

10. Development and Resources Corporation. 1968. Working Paper MD-6 Soils of the Mekong Delta and Their Characteristics Relative to Crop Production. New York.

11. Development and Resources Corporation. 1969. Mekong Delta Development Program. New York.

12. Einstein, H. A. 1964. River Sedimentation, Section 17-11 in Handbook of Applied Hydrology, (Ed. V. T. Chow). McGraw-Hill Book Company, New York.

13. Emery, K. O. and H. Niino. 1963. Sediments of the Gulf of Thailand and Ajacent Continental Shelf. Geological Society of America Bulletin. 74 : 541-554.

14. Engineer Agency for Resources Inventory. 1970. A Selected Annotated Bibliography, Agriculture. Washington.

15. Garrels, R. M. and C. L. Christ. 1965. Solutions, Minerals, and Equilibria. Pp. 360-362. Harper and Row, New York.

16. Gibbs, R. J. 1967. Quantitative X-Ray Diffraction Analysis Using Clay Mineral Standards Extracted from the Samples to be Analyzed. Clay Minerals Bulletin. 5 : 98-109.

17. Harada, W. T. 1970. Digital Simulation of Water Infiltration into Oxisols. A thesis submitted in partial fulfillment for the M. S. Degree, University of Hawaii, Honolulu, Hawaii.

18. Kassas, M. 1971. The Nile Ecological System: A Study Towards an International Programe. Biological Conservation. 4 : 19-25.

19. Kobayashi, T. 1960. Notes on the Geologic History of Thailand and Ajacent Territories. Japanese Journal of Geology and Geography, Transactions. 31(2-4) : 129-148.

20. Kempf, A. and P. Chevey. 1934. The Continental Shelf of French Indo-China and the relationship which Formerly Exhisted Between Indo-China and the East Indies. Proceedings of the 5th Pacific Science Congress. 2 : 849-852.

21. Kunze, R. J., G. Uehara, and K. Graham. 1968. Factors Important in the Calculation of Hydraulic Conductivity. Soil Science Society of America Proceedings. 32 : 760-764.

22. Mai-Thi and My-Nhung. 1966. Chemical and Physio-Chemical Changes in a Flooded Acid Sulfate Soil and the Growth and Yield of Rice. Vietnam: Ministry of Land Reform and Agriculture, Fishery and Animal Husbandry.

23. Michael, E. D. 1972. Viet Nam Geology and Mineral Resources. GeoTimes (February).

24. Moormen, F. D. 1961. The Soils of the Republic of Vietnam. Vietnam: Ministry of Agriculture.

25. Naval Oceanographic Office. 1961. Summary of Report Submitted by the Harza Engineering Company. Washington.

26. Norrish, K. and R. M. Taylor. 1962. Quantitative Analysis by X-Ray Diffraction. Clay Minerals Bulletin. 5 : 98-109.

27. Phum-Huu-Ann. 1964. Liming Experiments on Acid Sulfate Soils. Vietnam: Institute of Agricultural Research.

28. Pons, L. J. and W. Van der Keivie. 1969. Acid Sulfate Soils of Thailand. Thailand: Ministry of National Development.

29. Post, J. L. and R. L. Sloane. 1971. The Nature of Clay Soils from the Mekong Delta, An Giang Province, South Vietnam. Clay and Clay Minerals. 19 : 21-29.

30. Reginato, R. J. and C. H. M. van Bavel. 1962. Pressure Cell for Soil Cores. Soil Science Society of America Proceedings. 26 : 1-3.

31. Saukri, N. M. 1949. The Mineralogy of Some Nile Sediments. Quarterly Journal, Geological Society, London. 105 : 511-534.

32. Spurway, C. H. and K. Lawton. 1949. Soil Testing. Michigan State Technical Bulletin. 132 (4th Revision).

33. Stauffer, P. H. 1972. Southeast Asia. GeoTimes (August.

34. Taylor, R. M. and K. Norrish. 1966. The Measurements of Orientation Distribution and Its Application to Quantitative X-Ray Diffraction Analysis. Clay Minerals. 6 : 127-142.

35. Thsi-Cong-Tung. 1967. Natural Environment and Land Use in South Vietnam. Vietnam: Ministry of Agriculture.

36. The Netherlands Delta Team. 1971. Working Paper I.

37. The Netherlands Delta Team. 1972. Working Paper II.

38. Tsuji, G. Y. 1967. Measurements and Evaluation of Soil Water Transmission Coefficient on Some Hawaii Latosols. A Thesis Submitted in Partial Fulfillment for the M. S. Degree, University of Hawaii, Honolulu, Hawaii.

39. White, G. F. 1963. The Mekong River Plan. Scientific American. 208 : 49-59.

40. Workmen, D. R. 1972. Report No. 19, Geology of Laos, Cambodia, South Vietnam, and the Eastern Part of Thailand - A Review. Institute of Geological Sciences.

41. United States Department of the Interior. 1972. Pa Mong Phase II, Main Report. Washington.

42. United States Department of the Interior. 1972. Pa Mong Phase II, Appendix I, Land Resources. Washington.

43. United States Department of the Interior. 1972. Pa Mong Phase II, Appendix III, Hydrology and Climatology. Washington.

44. United States Department of the Interior. 1972. Pa Mong Phase II, Appendix IV, Geology. Washington.

APPENDIX A

Table A1

Multiple Regression and Associated R^2 for X-ray Analysis.
M = Montmorillonite + Chlorite, I = Mica, K = Kaolinite,
R = Rutile, F = Feldspar, H = Hematite, Q = Quartz.

Variable	Coefficient	Variable	Multiple R^2	Increase in R^2
Montmorillonite + Chlorite				
Constant	4.24196			
M	3.63353	M	0.8377	0.8377
M x K	- 0.04568	M x K	0.8518	0.0142
M x Q	- 0.25797	M x Q	0.8647	0.0129
Mica				
Constant	2.50453			
I	31.98392	I	0.4916	0.4916
I x K	- 0.46641	I x H	0.5261	0.0345
I x R	- 4.35170	I x K	0.5613	0.0353
I x H	0.09451	I x R	0.5825	0.0212
Kaolinite				
Constant	11.68685			
K	1.19843	K	0.0222	0.0222
K x M	- 0.08235	K x Q	0.0647	0.0425
K x Q	- 0.28026	K x M	0.0960	0.0313
Rutile				
Constant	5.13037			
R	6.51879	R	0.1672	0.1672
R x M	1.29773	R x I	0.2769	0.1097
R x I	-11.24299	R x M	0.3481	0.0713
Feldspar				
Constant	4.73202			
F	1.20929	F	0.1132	0.1132
F x I	0.44386	F x K	0.3719	0.2587
F x K	- 0.07163	F x I	0.4053	0.0334
F x R	0.18085	F x R	0.4176	0.0123
Hematite				
Constant	3.21280			
H	- 2.31168	H	0.0001	0.0001
H x F	3.47139	H x F	0.2883	0.2881
Quartz				
Constant	9.46458			
Q	43.59111	Q	0.2701	0.2701
Q x I	-22.93518	Q x F	0.7429	0.4728
Q x F	- 2.03921	Q x I	0.7627	0.0198

APPENDIX B

Table B1

Multiple Regression and Associated R^2 for Total Analysis

Variable	Coefficient	Variable	Multiple R^2	Increase in R^2
Sodium				
Constant	4.29719			
Na	12.10210	Na	,8054	.8054
Na x Mg	- 0.56362	Na x Fe	,9139	.1085
Na x Al	- 0,89494	Na x Mn	,9228	,0089
Na x Si	- 0,31986	Na x P	,9366	.0138
Na x P	2.52814	Na x Mg	,9414	,0048
Na x K	- 0,57723	Na x K	.9500	.0086
Na x Ca	- 0.74185	Na x Al	.9670	.0170
Na x Ti	0.33159	Na x Ca	,9869	.0199
Na x Mn	2,83703	Na x Si	,9881	.0012
Na x Fe	- 2.30446	Na x Ti	,9888	.0008
Magnesium				
Constant	- 0,06108			
Mg	6.27403	Mg	.9754	.9754
Mg x Na	0,45241	Mg x P	.9842	.0088
Mg x Al	- 0.35912	Mg x Al	.9938	.0097
Mg x P	0.30332	Mg X Na	.9945	.0007
Mg x Ca	- 0,29756	Mg x Ti	.9949	.0004
Mg x Ti	- 0.59229	Mg x Ca	,9953	.0004
Mg x Mn	1,46473	Mg x Mn	,9960	.0007
Aluminum				
Constant	1,96623			
Al	2.50484	Al	.8869	,8869
Al x Na	0.45241	Al x Fe	.8942	.0072
Al x Mg	- 0.10118	Al x Mg	.9192	.0250
Al x Si	- 0.17131	Al x Ti	.9306	.0115
Al x P	- 0.65599	Al x Ca	.9320	.0013
Al x K	0.08555	Al x P	,9332	,0012
Al x Ca	0.15108	Al x K	,9377	.0045
Al x Mn	- 0.72098	Al x Si	.9401	.0024
Al x Fe	0.27691	Al x Mn	.9406	.0006

Table B1, Continued

Multiple Regression and Associated R^2 for Total Analysis

Variable	Coefficient	Variable	Multiple R^2	Increase in R^2
Silica				
Constant	5.29318			
Si	10.12247	Si	.9748	.9748
Si x Na	- 0.51861	Si x P	.9788	.0040
Si x Mg	- 0.14885	Si x Mg	.9836	.0048
Si x Al	- 0.14659	Si x Na	.9857	.0021
Si x P	0.41713	Si x Ti	.9867	.0011
Si x K	- 0.15228	Si x Fe	.9916	.0049
Si x Ca	- 0.33882	Si x Ca	.9919	.0003
Si x Ti	- 0.87167	Si x K	.9933	.0014
Si x Mn	0.58624	Si x Mn	.9935	.0002
Si x Fe	0.16937	Si x Al	.9939	.0004
Phosphorus				
Constant	0.07912			
P	- 0.39026	P	.9581	.9581
P x Na	0.19710	P x Al	.9769	.0187
P x Mg	- 0.09690	P x Fe	.9812	.0043
P x Al	- 0.08800	P x Si	.9848	.0036
P x Si	0.20933	P x Ca	.9872	.0024
P x K	- 0.06954	P x Na	.9904	.0032
P x Ca	0.19278	P x K	.9912	.0008
P x Ti	0.43435	P x Ti	.9915	.0003
P x Fe	- 0.20126	P x Mg	.9918	.0003
Potassium				
Constant	0.10550			
K	1.24169	K	.9834	.9834
K x Na	- 0.30891	K x Ti	.9853	.0019
K x Mg	0.04000	K x Fe	.9900	.0047
K x P	0.33418	K x Ca	.9932	.0032
K x Ca	- 0.15216	K x P	.9963	.0031
K x Ti	- 0.37739	K x Na	.9978	.0015
K x Mn	0.36002	K x Mn	.9990	.0012
K x Fe	0.07703	K x Mg	.9994	.0004

Table B1, Continued

Multiple Regression and Associated R^2 for Total Analysis

Variable	Coefficient	Variable	Multiple R^2	Increase in R^2
Calcium				
Constant	- 0.08471			
Ca	3.74752	Ca	.9929	.9929
Ca x Na	0.29139	Ca x K	.9965	.0036
Ca x Mg	- 0.07257	Ca x Mg	.9979	.0013
Ca x K	- 0.00127	Ca x Ti	.9985	.0007
Ca x Ti	- 0.08342	Ca x Na	.9992	.0007
Ca x Fe	- 0.11821	Ca x Fe	.9994	.0002
Titanium				
Constant	0.30345			
Ti	4.02374	Ti	.9745	.9745
Ti x Na	- 0.76178	Ti x P	.9803	.0058
Ti x Mg	- 0.20717	Ti x Na	.9837	.0034
Ti x Al	- 0.29560	Ti x Ca	.9867	.0029
Ti x Si	0.23516	Ti x Si	.9943	.0076
Ti x P	1.36201	Ti x Mg	.9956	.0013
Ti x K	- 0.21155	Ti x Al	.9972	.0017
Ti x Ca	0.12020	Ti x K	.9980	.0008
Manganese				
Constant	0.02169			
Mn	0.40708	Mn	.9785	.9785
Mn x Na	0.03175	Mn x Mg	.9944	.0159
Mn x Mg	- 0.00101	Mn x Ca	.9954	.0009
Mn x Si	- 0.02777	Mn x Fe	.9968	.0014
Mn x P	- 0.04398	Mn x Si	.9978	.0010
Mn x Ca	0.02026	Mn x P	.9982	.0004
Mn x Ti	0.02141	Mn x Na	.9989	.0007
Mn x Fe	- 0.02484	Mn x Ti	.9992	.0003

Table B1, Continued

Multiple Regression and Associated R^2 for Total Analysis

Variable	Coefficient	Variable	Multiple R^2	Increase in R^2
Iron				
Constant	- 3,49710			
Fe	- 4.48137	Fe	,9688	.9688
Fe x Na	1,58123	Fe x Na	,9708	,0020
Fe x Mg	0,40164	Fe x Mn	,9725	.0017
Fe x Al	0,38316	Fe x P	.9758	.0034
Fe x Si	0.68793	Fe x Mg	,9765	,0007
Fe x P	- 2.03699	Fe x K	,9774	,0009
Fe x K	0,73149	Fe x Al	,9784	,0010
Fe x Ca	0.98451	Fe x Ca	,9811	.0027
Fe x Ti	0.69425	Fe x Si	,9830	,0019
Fe x Mn	- 2.85872	Fe x Ti	,9849	.0018

APPENDIX C

Table C1

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

DEPTH	(cm)	LONG MY (0-10)	LONG MY (10-25)	LONG MY (25-43)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.10	0.00	0.00
COARSE SAND	(1-0.5mm)	0.40	0.30	0.20
MEDIUM SAND	(0.5-0.25mm)	0.40	0.40	0.30
FINE SAND	(0.25-0.10mm)	1.00	1.00	0.60
V. FINE SAND	(0.10-0.05mm)	1.40	1.20	0.70
TOTAL SAND	(2-0.05mm)	3.30	2.90	1.80
SILT	(0.05-0.002mm)	41.2	38.3	39.7
CLAY	(less than 0.002mm)	55.5	58.8	59.5
TEXTURAL CLASS(Lab)		SiC	C	C
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.10	0.05	0.05
SETTLING VOLUME	(ml)	32.0	31.0	34.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		64.0	65.0	56.7
1/3 BAR		49.0	45.8	43.6
15 BAR		30.3	30.2	27.9
SOIL REACTION	(pH)			
1:1 H2O		4.50	4.70	4.30
1:1 IN KCl		3.70	3.80	3.60
1:2 0.01 M CaCl2		4.50	4.40	4.20
ORGANIC CARBON	(percent)	3.40	2.46	1.49
AVAILABLE PHOSPHORUS	(ppm)	22.8	9.60	4.00
ACTIVE IRON	(percent)	0.58	0.62	0.80
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		77.9	91.2	80.8
ECe @ 25°C		3.28	1.77	1.84
SUM OF SOLUBLE BASES	(me/100g)	2.56	1.61	1.49
EXCHANGEABLE AL+++	(me/100g)	1.42	1.70	2.61
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	12.1	11.3	10.0

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

		LONG MY	LONG MY	LONG MY
CATION EXCHANGE CAPACITY BY				
NH4)Ac	(me/100g)	25.0	24.8	23.4
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	5.36	4.11	3.24
Mg+++	(me/100g)	11.2	11.2	13.0
Na+	(me/100g)	0.94	0.76	0.87
K+	(me/100g)	0.49	0.38	0.44
BASE SATURATION PERCENTAGE		61.7	59.8	68.6
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	1.34	1.71	1.96
H+	(me/100g)	0.24	0.42	0.35
AL+++	(me/100g)	1.10	1.29	1.61
EXTRACTABLE BASES BY IN KCl				
Ca++	(me/100g)	6.36	5.19	3.92
Mg++	(me/100g)	11.5	11.7	13.6

Table Cl, Continued

Physical and Chemical Properties of Selected Soil Samples
From Long Xuyen Transect

DEPTH	(cm)	CAI SAN (0-15)	CAI SAN (15-30)	CAI SAN (30-46)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.00	0,00	0,00
COARSE SAND	(1-0,5mm)	0,30	0.10	0,10
MEDIUM SAND	(0,5-0.25mm)	0.40	0,20	0.20
FINE SAND	(0.25-0.10mm)	0.90	0.70	1.00
V. FINE SAND	(0.10-0,05mm)	1,40	1.10	1.40
TOTAL SAND	(2-0.05mm)	3,00	2.10	2,70
SILT	(0.05-0.002mm)	30.3	29.2	41.6
CLAY	(less than 0.002mm)	66.7	68.7	55,7
TEXTURAL CLASS(Lab)		C	C	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.10	0,05	0,05
SETTLING VOLUME	(ml)	28,0	31,0	34.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		60.5	58,1	55.9
1/3 BAR		47.7	48.7	42,7
15 BAR		31.7	29,9	26.2
SOIL REACTION	(pH)			
1:1 H2O		4,70	4.60	4.30
1:1 1N KCl		4.10	4,00	3.70
1:2 0.01 M CaCl2		4.60	4.50	4,20
ORGANIC CARBON	(percent)	2.77	1.27	0,50
AVAILABLE PHOSPHORUS	(ppm)	6.80	4,50	2,20
ACTIVE IRON	(percent)	0.56	1.18	2.69
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		83.6	85.3	77,3
ECe @ 25°C		1.91	2,28	2.60
SUM OF SOLUBLE BASES	(me/100g)	1.60	1.94	2.01
EXCHANGEABLE AL+++	(me/100g)	0.68	1.53	1,06
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	8.81	10,2	8.14

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

		CAI SAN	CAI SAN	CAI SAN
CATION EXCHANGE CAPACITY BY				
NH4OAc	(me/100g)	27.1	25.0	19.5
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	6.55	6.18	4.19
Mg+++	(me/100g)	12.3	15.1	14.0
Na+	(me/100g)	0.70	0.80	0.76
K+	(me/100g)	0.52	0.54	0.56
BASE SATURATION PERCENTAGE		68.2	82.7	89.7
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	0.53	1.18	1.11
H+	(me/100g)	0.10	0.16	0.19
AL+++	(me/100g)	0.43	1.02	0.92
EXTRACTABLE BASES BY IN KCl				
Ca++	(me/100g)	8.13	5.89	4.54
Mg++	(me/100g)	13.0	15.5	14.7

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

DEPTH	(cm)	PHUNG HIEP (0-10)	PHUNG HIEP (10-20)	PHUNG HIEP (20-38)	PHUNG HIEP (38-61)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	0.00	0.00	0.00	0.00
COARSE SAND	(1-0.5mm)	0.50	0.40	0.00	0.00
MEDIUM SAND	(0.5-0.25mm)	0.50	0.50	0.10	0.10
FINE SAND	(0.25-0.10mm)	1.40	1.20	0.20	0.20
V. FINE SAND	(0.10-0.05mm)	1.70	1.40	0.40	0.50
TOTAL SAND	(2-0.05mm)	4.10	3.50	0.70	0.80
SILT	(0.05-0.002mm)	37.3	35.4	34.8	41.5
CLAY	(less than 0.002mm)	58.6	61.2	64.5	57.7
TEXTURAL CLASS(Lab)		C	C	C	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		0.05	0.05	0.05	0.05
SETTLING VOLUME	(ml)	30.0	29.0	32.0	35.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		74.6	75.6	60.4	54.7
1/3 BAR		51.9	52.9	45.2	43.6
15 BAR		31.6	32.0	27.8	26.1
SOIL REACTION	(pH)				
1:1 H2O		4.80	5.00	5.10	5.50
1:1 IN KCl		3.90	4.30	4.30	4.30
1:2 0.01 M CaCl2		4.60	4.80	5.00	5.10
ORGANIC CARBON	(percent)	3.57	3.03	1.09	0.52
AVAILABLE PHOSPHORUS	(ppm)	6.20	8.20	4.60	2.50
ACTIVE IRON	(percent)	0.67	0.56	0.96	1.98
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		88.9	82.9	85.9	79.8
ECe @ 25°C		1.70	1.84	2.35	2.54
SUM OF SOLUBLE BASES	(me/100g)	1.51	1.52	2.02	2.07
EXCHANGEABLE AL+++	(me/100g)	0.56	0.16	0.19	0.23
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	11.2	10.1	7.32	6.12

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

		PHUNG HIEP	PHUNG HIEP	PHUNG HIEP	PHUNG HIEP
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	28,6	27,9	22,6	21.3
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	9,10	9.01	7,06	6,16
Mg+++	(me/100g)	10,7	12,9	15,1	15,4
Na+	(me/100g)	0.60	0.80	0.94	0,98
K+	(me/100g)	0,41	0,43	0.44	0.53
BASE SATURATION PERCENTAGE		67,5	77,5	95,2	98.6
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	0,51	0,15	0.19	0,20
H+	(me/100g)	0,14	0.02	0.06	0.04
AL+++	(me/100g)	0.37	0,13	0,13	0.16
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	10.4	9.96	7,48	6,35
Mg++	(me/100g)	11,0	13.7	15.6	15.9

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

DEPTH	(cm)	CAI BE (4-10)	CAI BE (10-28)	CAI BE (28-36)	CAI BE (36-64)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	0.00	0.10	0.00	0.00
COARSE SAND	(1-0.5mm)	0.50	0.40	0.50	0.10
MEDIUM SAND	(0.5-0.25mm)	0.50	0.50	0.70	0.20
FINE SAND	(0.25-0.10mm)	1.50	1.30	1.30	0.40
V. FINE SAND	(0.10-0.05mm)	2.10	1.30	1.40	1.00
TOTAL SAND	(2-0.05mm)	4.60	3.60	3.90	1.70
SILT	(0.05-0.002mm)	36.3	34.7	35.4	44.1
CLAY	(less than 0.002mm)	59.1	61.7	60.7	54.2
TEXTURAL CLASS(Lab)		C	C	C	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		0.05	0.11	0.05	0.05
SETTLING VOLUME	(ml)	36.0	39.0	36.0	34.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		68.0	62.1	64.4	53.5
1/3 BAR		51.5	48.8	48.4	39.4
15 BAR		31.9	29.8	30.2	23.8
SOIL REACTION	(pH)				
1:1 H2O		4.50	5.10	4.50	4.30
1:1 1N KCl		3.90	4.40	3.70	3.60
1:2 0.01 M CaCl2		4.50	5.10	4.40	4.20
ORGANIC CARBON	(percent)	4.28	2.99	3.16	0.61
AVAILABLE PHOSPHORUS	(ppm)	7.60	7.50	8.90	2.90
ACTIVE IRON	(percent)	0.74	0.82	0.79	1.27
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		103.	142.	88.3	77.4
ECe @ 25°C		2.37	1.60	2.71	2.91
SUM OF SOLUBLE BASES	(me/100g)	2.44	2.27	2.39	2.25
EXCHANGEABLE AL+++	(me/100g)	0.54	0.15	1.67	1.92
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	14.0	10.4	13.8	8.51

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

		CAI BE	CAI BE	CAI BE	CAI BE
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	29.8	28.8	31.2	19.1
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	10.7	9.64	7.93	5.88
Mg+++	(me/100g)	9.50	11.2	12.2	12.0
Na+	(me/100g)	0.54	0.84	1.03	0.87
K+	(me/100g)	0.46	0.33	0.29	0.39
BASE SATURATION PERCENTAGE		63.0	68.5	61.1	88.4
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	0.56	0.16	1.24	1.57
H+	(me/100g)	0.20	0.03	0.23	0.38
AL+++	(me/100g)	0.36	0.13	1.01	1.19
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	11.8	11.0	9.23	6.31
Mg++	(me/100g)	9.81	12.2	13.2	12.1

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

DEPTH	(cm)	LONG XUYEN (0-15)	LONG XUYEN (15-28)	LONG XUYEN (28-46)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.00	0.10	0.00
COARSE SAND	(1-0.5mm)	0.30	0.10	0.10
MEDIUM SAND	(0.5-0.25mm)	0.20	0.20	0.40
FINE SAND	(0.25-0.10mm)	0.50	0.50	0.90
V. FINE SAND	(0.10-0.05mm)	2.10	2.70	2.90
TOTAL SAND	(2-0.05mm)	3.10	3.60	4.30
SILT	(0.05-0.002mm)	68.1	63.7	58.3
CLAY	(less than 0.002mm)	28.8	32.7	37.4
TEXTURAL CLASS(Lab)		SiCl	SiCl	SiCl
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.20	0.15	0.20
SETTLING VOLUME	(ml)	27.0	24.0	24.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		50.6	42.8	42.3
1/3 BAR		39.7	33.8	33.7
15 BAR		14.9	16.0	18.2
SOIL REACTION	(pH)			
1:1 H_2O		4.80	5.30	5.50
1:1 1N KCl		3.70	4.20	4.20
1:2 0.01 M $CaCl_2$		4.30	5.00	5.20
ORGANIC CARBON	(percent)	1.23	0.79	0.61
AVAILABLE PHOSPHORUS	(ppm)	10.2	10.9	11.9
ACTIVE IRON	(percent)	1.54	1.56	1.50
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		62.2	59.6	60.5
ECe @ 25°C		0.31	0.30	0.37
SUM OF SOLUBLE BASES	(me/100g)	0.19	0.18	0.22
EXCHANGEABLE Al^{+++}	(me/100g)	0.98	0.22	0.09
TITRATABLE ACIDITY BY $BaCl_2$·TEA @ pH 8.0	(me/100g)	6.42	5.00	4.26

Table C1, Continued

Physical and Chemical Properties of Selected Soil Samples From Long Xuyen Transect

		LONG XUYEN	LONG XUYEN	LONG XUYEN
CATION EXCHANGE CAPACITY BY				
NH4OAc	(me/100g)	12.1	12.2	14.7
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	5.60	7.06	8.77
Mg+++	(me/100g)	1.77	2.48	3.65
Na+	(me/100g)	0.26	0.20	0.18
K+	(me/100g)	0.16	0.16	0.19
BASE SATURATION PERCENTAGE		62.8	79.7	85.5
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	0.72	0.20	0.10
H+	(me/100g)	0.21	0.00	0.01
AL+++	(me/100g)	0.51	0.20	0.09
EXTRACTABLE BASES BY IN KCL				
Ca++	(me/100g)	5.31	6.74	8.48
Mg++	(me/100g)	1.82	2.62	3.75

Table C2

Physical and Chemical Properties of Selected Soil Samples From Cantho Transect

		LONG XUYEN	LONG XUYEN	LONG XUYEN
DEPTH	(cm)	(0-15)	(15-41)	(41-51)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.10	0.00	0.00
COARSE SAND	(1-0.5mm)	0.30	0.10	0.10
MEDIUM SAND	(0.5-0.25mm)	0.20	0.10	0.00
FINE SAND	(0.25-0.10mm)	0.70	0.10	0.10
V. FINE SAND	(0.10-0.05mm)	0.80	0.10	0.20
TOTAL SAND	(2-0.05mm)	2.10	0.40	0.40
SILT	(0.05-0.002mm)	52.1	39.9	37.0
CLAY	(less than 0.002mm)	45.8	59.7	62.6
TEXTURAL CLASS(Lab)		SiC	C	C
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.10	0.05	0.05
SETTLING VOLUME	(ml)	27.0	27.0	37.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		58.4	49.4	55.5
1/3 BAR		45.5	35.3	39.2
15 BAR		22.1	21.8	23.7
SOIL REACTION	(pH)			
1:1 H2O		4.80	6.20	6.00
1:1 IN KCl		3.70	5.00	5.20
1:2 0.01 M CaCl2		4.50	6.10	6.00
ORGANIC CARBON	(percent)	1.53	0.34	0.36
AVAILABLE PHOSPHORUS	(ppm)	4.50	4.20	2.90
ACTIVE IRON	(percent)	1.52	1.50	2.10
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		80.2	45.1	119.
ECe @ 25°C		3.25	1.89	2.40
SUM OF SOLUBLE BASES	(me/100g)	2.61	0.85	2.86
EXCHANGEABLE AL+++	(me/100g)	0.63	0.00	0.00
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	6.12	3.21	3.36

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples
From Cantho Transect

		LONG XUYEN	LONG XUYEN	LONG XUYEN
CATION EXCHANGE CAPACITY BY				
NH4OAc	(me/100g)	16.2	17.0	41.3
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	8.36	9.63	9.59
Mg+++	(me/100g)	4.22	6.18	6.55
Na+	(me/100g)	1.54	2.14	2.58
K+	(me/100g)	0.19	0.20	0.20
BASE SATURATION PERCENTAGE		72.2	102.	38.9
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	0.65	0.03	0.01
H+	(me/100g)	0.13	0.03	0.00
AL+++	(me/100g)	0.52	0.00	0.01
EXTRACTABLE BASES BY IN KCl				
Ca++	(me/100g)	8.14	9.31	9.26
Mg++	(me/100g)	4.38	6.02	6.64

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples
From Cantho Transect

DEPTH	(cm)	CAI BE (0-28)	CAI BE (28-41)
PARTICLE SIZE	(percent)		
V. COARSE SAND	(2-1mm)	0.10	0.00
COARSE SAND	(1-0.5mm)	0.20	0.10
MEDIUM SAND	(0.5-0.25mm)	0.20	0.20
FINE SAND	(0.25-0.10mm)	0.40	0.40
V. FINE SAND	(0.10-0.05mm)	0.90	1.40
TOTAL SAND	(2-0.05mm)	1.80	2.10
SILT	(0.05-0.002mm)	38.3	41.9
CLAY	(less than 0.002mm)	59.9	56.0
TEXTURAL CLASS(Lab)		C	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)		
24th HOUR		0.05	0.05
SETTLING VOLUME	(ml)	34.0	27.0
MOISTURE RETENTION	(100Xgm/gm)		
1/10 BAR		71.0	66.3
1/3 BAR		49.3	46.4
15 BAR		29.3	27.6
SOIL REACTION	(pH)		
1:1 H_2O		5.20	6.60
1:1 1N KCl		4.30	5.80
1:2 0.01 M $CaCl_2$		5.00	6.40
ORGANIC CARBON	(percent)	2.18	0.68
AVAILABLE PHOSPHORUS	(ppm)	3.30	2.50
ACTIVE IRON	(percent)	1.00	6.72
SATURATION EXTRACT	(mmhos/cm)		
SATURATION PERCENTAGE		86.9	92.0
ECe @ 25°C		0.62	0.59
SUM OF SOLUBLE BASES	(me/100g)	0.54	0.54
EXCHANGEABLE AL^{+++}	(me/100g)	0.27	0.00
TITRATABLE ACIDITY BY $BaCl_2$·TEA @ pH 8.0	(me/100g)	7.09	3.73

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples From Cantho Transect

		CAI BE	CAI BE
CATION EXCHANGE CAPACITY BY			
NH4OAc	(me/100g)	16,8	22.3
EXCHANGEABLE CATIONS BY			
Ca+++	(me/100g)	12,2	15.1
Mg+++	(me/100g)	5,48	5.67
Na+	(me/100g)	0.51	0.45
K+	(me/100g)	0.18	0.33
BASE SATURATION PERCENTAGE		106.	94.2
EXCHANGE ACIDITY BY IN KCl			
TOTAL	(me/100g)	0,00	0.26
H+	(me/100g)	0,00	0.07
AL+++	(me/100g)	0,00	0,19
EXTRACTABLE BASES BY IN KCl			
Ca++	(me/100g)	11,6	11.0
Mg++	(me/100g)	5.39	4.26

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples
From Cantho Transect

		CAI LAY	CAI LAY	CAI LAY
DEPTH	(cm)	(0-15)	(15-28)	(28-51)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.00	0.10	0.10
COARSE SAND	(1-0.5mm)	1.10	0.20	1.30
MEDIUM SAND	(0.5-0.25mm)	2.30	0.70	1.90
FINE SAND	(0.25-0.10mm)	2.60	0.60	1.40
V. FINE SAND	(0.10-0.05mm)	7.00	1.90	5.90
TOTAL SAND	(2-0.05mm)	43.5	48.5	47.1
SILT	(0.05-0.002mm)	49.5	49.6	47.0
CLAY	(less than 0.002mm)			
TEXTURAL CLASS(Lab)		SiC	SiC	
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.25	0.05	0.05
SETTLING VOLUME	(ml)	36.0	28.0	29.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		77.0	47.4	48.0
1/3 BAR		51.3	37.4	38.9
15 BAR		29.4	23.1	24.1
SOIL REACTION	(pH)			
1:1 H2O		4.60	4.40	4.20
1:1 IN KCl		4.00	3.70	3.60
1:2 0.01 M CaCl2		4.40	4.30	4.00
ORGANIC CARBON	(percent)	5.54	1.02	0.94
AVAILABLE PHOSPHORUS	(ppm)	5.80	3.50	2.20
ACTIVE IRON	(percent)	0.47	1.27	2.50
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		100.	110.	80.9
ECe @ 25°C		2.18	1.65	1.70
SUM OF SOLUBLE BASES	(me/100g)	2.18	1.81	1.38
EXCHANGEABLE AL+++	(me/100g)	0.68	1.78	2.13
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	12.4	7.02	8.06

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples From Cantho Transect

		CAI LAY	CAI LAY	CAI LAY
CATION EXCHANGE CAPACITY BY				
NH4OAc	(me/100g)	27.2	15.3	16.1
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	10.9	5.57	5.55
Mg+++	(me/100g)	5.21	5.23	5.77
Na+	(me/100g)	0.70	0.73	0.84
K+	(me/100g)	0.32	0.29	0.30
BASE SATURATION PERCENTAGE		55.0	65.4	68.8
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	0.51	1.41	1.71
H+	(me/100g)	0.16	0.30	0.36
AL+++	(me/100g)	0.35	1.11	1.35
EXTRACTABLE BASES BY IN KCl				
Ca++	(me/100g)	10.8	5.86	5.58
Mg++	(me/100g)	5.18	5.30	5.58

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples From Cantho Transect

DEPTH	(cm)	LONG MY (0-10)	LONG MY (10-25)	LONG MY (25-41)	LONG MY (41-51)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	0.10	0.00	0.00	0.00
COARSE SAND	(1-0.5mm)	0.50	0.10	0.10	0.10
MEDIUM SAND	(0.5-0.25mm)	0.30	0.20	0.30	0.20
FINE SAND	(0.25-0.10mm)	2.00	2.70	3.60	1.70
V. FINE SAND	(0.10-0.05mm)	4.60	4.90	6.10	2.60
TOTAL SAND	(2-0.05mm)	7.50	7.90	10.1	4.60
SILT	(0.05-0.002mm)	44.1	43.8	45.1	45.5
CLAY	(less than 0.002mm)	48.4	48.3	44.8	49.9
TEXTURAL CLASS(Lab)		SiC	SiC	SiC	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		0.05	0.10	0.10	0.05
SETTLING VOLUME	(ml)	27.0	28.0	27.0	25.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		53.1	57.8	42.3	45.9
1/3 BAR		42.0	41.0	33.7	35.9
15 BAR		24.4	24.9	19.9	21.2
SOIL REACTION	(pH)				
1:1 H2O		5.10	5.40	5.30	5.50
1:1 1N KCl		4.40	4.70	4.50	4.70
1:2 0.01 M CaCl2		4.90	5.40	5.30	5.40
ORGANIC CARBON	(percent)	2.94	2.71	0.63	0.30
AVAILABLE PHOSPHORUS	(ppm)	9.00	21.2	8.20	4.20
ACTIVE IRON	(percent)	0.39	0.28	0.35	1.15
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		74.9	75.2	66.5	72.6
ECe @ 25°C		1.70	2.35	2.61	2.08
SUM OF SOLUBLE BASES	(me/100g)	1.27	1.77	1.74	1.51
EXCHANGEABLE AL+++	(me/100g)	0.12	0.08	0.07	0.06
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	7.99	7.09	4.03	3.58

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples From Cantho Transect

		LONG MY	LONG MY	LONG MY	LONG MY
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	54.7	22.4	14.5	17.0
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	13.0	15.1	11.1	12.4
Mg+++	(me/100g)	4.05	3.95	3.20	3.74
Na+	(me/100g)	0.31	0.57	0.51	0.54
K+	(me/100g)	0.23	0.21	0.21	0.26
BASE SATURATION PERCENTAGE		29.8	80.6	91.6	90.8
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	0.17	0.07	0.10	0.05
H+	(me/100g)	0.05	0.07	0.01	0.00
AL+++	(me/100g)	0.12	0.00	0.09	0.05
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	16.1	16.5	10.9	11.6
Mg++	(me/100g)	4.00	4.03	3.38	3.77

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples
From Cantho Transect

DEPTH	(cm)	LONG XUYEN (0-15)	LONG XUYEN (15-30)	LONG XUYEN (30-48)
PARTICLE SIZE	(percent)			
V. COARSE SAND	(2-1mm)	0.00	0.10	0.00
COARSE SAND	(1-0.5mm)	0.10	0.20	0.10
MEDIUM SAND	(0.5-0.25mm)	0.10	0.10	0.10
FINE SAND	(0.25-0.10mm)	0.30	0.20	0.00
V. FINE SAND	(0.10-0.05mm)	0.40	0.20	0.40
TOTAL SAND	(2-0.05mm)	0.90	0.80	0.60
SILT	(0.05-0.002mm)	46.9	32.7	38.2
CLAY	(less than 0.002mm)	52.5	66.5	61.2
TEXTURAL CLASS(Lab)		SiC	C	C
HYDRAULIC CONDUCTIVITY	(cm/hr)			
24th HOUR		0.05	0.05	0.05
SETTLING VOLUME	(ml)	26.0	34.0	30.0
MOISTURE RETENTION	(100Xgm/gm)			
1/10 BAR		52.6	54.2	46.3
1/3 BAR		43.8	44.3	42.1
15 BAR		26.2	25.9	23.3
SOIL REACTION	(pH)			
1:1 H2O		5.50	6.20	6.40
1:1 1N KCl		4.10	5.20	5.30
1:2 0.01 M CaCl2		4.90	5.70	6.00
ORGANIC CARBON	(percent)	1.13	0.46	0.30
AVAILABLE PHOSPHORUS	(ppm)	4.80	5.40	2.80
ACTIVE IRON	(percent)	1.46	1.44	1.10
SATURATION EXTRACT	(mmhos/cm)			
SATURATION PERCENTAGE		73.1	74.6	76.0
ECe @ 25°C		0.40	0.55	0.56
SUM OF SOLUBLE BASES	(me/100g)	0.29	0.41	0.42
EXCHANGEABLE AL+++	(me/100g)	0.24	0.04	0.05
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	6.87	5.15	2.99

Table C2, Continued

Physical and Chemical Properties of Selected Soil Samples
From Cantho Transect

		LONG XUYEN	LONG XUYEN	LONG XUYEN
CATION EXCHANGE CAPACITY BY				
NH4OAc	(me/100g)	18.2	20.0	18.6
EXCHANGEABLE CATIONS BY				
Ca+++	(me/100g)	9.96	12.5	11.6
Mg+++	(me/100g)	4.42	6.78	7.75
Na+	(me/100g)	0.28	0.48	0.51
K+	(me/100g)	0.23	0.31	0.28
BASE SATURATION PERCENTAGE		80.3	98.3	106.
EXCHANGE ACIDITY BY IN KCl				
TOTAL	(me/100g)	0.20	0.02	0.01
H+	(me/100g)	0.04	0.00	0.01
AL+++	(me/100g)	0.16	0.02	0.00
EXTRACTABLE BASES BY IN KCl				
Ca++	(me/100g)	9.52	15.8	11.3
Mg++	(me/100g)	4.50	7.19	7.73

Table C3

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

DEPTH	(cm)	CAI LAY (0-18)	CAI LAY (18-33)	CAI LAY (33-56)	CAI LAY (0-18)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	0,90	0.90	1,20	0.00
COARSE SAND	(1-0.5mm)	0,80	2.30	1.70	0,30
MEDIUM SAND	(0.5-0.25mm)	2,50	2,40	1.50	0.20
FINE SAND	(0.25-0.10mm)	64,2	70.0	67.5	0.50
V. FINE SAND	(0,10-0.05mm)	20,2	11.2	18.2	0,50
TOTAL SAND	(2-0.05mm)	88,6	86.8	90.1	1,50
SILT	(0,05-0.002mm)	6,30	5,50	5,40	33,0
CLAY	(less than 0,002mm)	5.10	7.70	4.50	65,5
TEXTURAL CLASS (Lab)		S	LS	S	C
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		3.50	10,4	13,0	0,05
SETTLING VOLUME	(ml)	28,0	12,0	12.0	25.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		24,0	24.5	30.7	63,9
1/3 BAR		9.46	6.27	5.52	45,7
15 BAR		2.80	3.60	2.70	26.2
SOIL REACTION	(pH)				
1:1 H_2O		4,50	5.70	6.10	5,00
1:1 IN KCl		3.80	5.30	5.80	4.50
1:2 0.01 M $CaCl_2$		4.10	5.50	5,90	4.80
ORGANIC CARBON	(percent)	0,61	0.14	0.08	1.70
AVAILABLE PHOSHORUS	(ppm)	34.6	2.30	1.90	11,3
ACTIVE IRON	(percent)	0,74	2,28	1.85	1.02
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		20.6	27.0	30.0	87.6
ECe @ 25°C		0.67	0.58	0.52	3,73
SUM OF SOLUBLE BASES	(me/100g)	0.14	0.16	0.16	3.27
EXCHANGEABLE AL^{+++}	(me/100g)	0.41	0.03	0.03	0,14
TITRATABLE ACIDITY BY $BaCl_2 \cdot TEA$ @ pH 8.0	(me/100g)	2,09	1.12	0.67	7,39

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples
From My Tho Transect

		CAI LAY	CAI LAY	CAI LAY	CAI LAY
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	2.30	1.10	1.10	25.8
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	0.33	0.58	0.72	6.26
Mg+++	(me/100g)	0.12	0.08	0.86	19.3
Na+	(me/100g)	0.13	0.10	0.10	1.84
K+	(me/100g)	0.04	0.02	0.02	0.24
BASE SATURATION PERCENTAGE		20.9	56.3	140.	94.4
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	0.39	0.01	0.01	0.12
H+	(me/100g)	0.13	0.01	0.01	0.04
AL+++	(me/100g)	0.26	0.00	0.00	0.08
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	0.39	0.67	0.64	6.69
Mg++	(me/100g)	0.20	0.18	0.16	19.5

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples
From My Tho Transect

		CAI LAY	CAI LAY
DEPTH	(cm)	(18-36)	(36-53)
PARTICLE SIZE	(percent)		
V. COARSE SAND	(2-1mm)	0.00	0.00
COARSE SAND	(1-0.5mm)	0.10	0.10
MEDIUM SAND	(0.5-0.25mm)	0.20	0.10
FINE SAND	(0.25-0.10mm)	1.00	0.50
V. FINE SAND	(0.10-0.05mm)	1.10	1.30
TOTAL SAND	(2-0.05mm)	2.40	2.00
SILT	(0.05-0.002mm)	32.3	32.0
CLAY	(less than 0.002mm)	65.3	66.0
TEXTURAL CLASS(Lab)		C	C
HYDRAULIC CONDUCTIVITY	(cm/hr)		
24th HOUR		0.05	0.05
SETTLING VOLUME	(ml)	28.0	26.0
MOISTURE RETENTION	(100Xgm/gm)		
1/10 BAR		53.6	56.2
1/3 BAR		43.6	44.7
15 BAR		25.8	26.8
SOIL REACTION	(pH)		
1:1 H2O		4.80	4.80
1:1 IN KCl		4.10	4.00
1:2 0.01 M CaCl2		4.70	4.60
ORGANIC CARBON	(percent)	0.61	0.44
AVAILABLE PHOSPHORUS	(ppm)	3.60	2.00
ACTIVE IRON	(percent)	1.82	1.46
SATURATION EXTRACT	(mmhos/cm)		
SATURATION PERCENTAGE		86.4	107.
ECe @ 25°C		3.09	3.59
SUM OF SOLUBLE BASES	(me/100g)	2.67	3.84
EXCHANGEABLE AL+++	(me/100g)	0.40	0.44
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	7.91	7.47

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

		CAI LAY	CAI LAY
CATION EXCHANGE CAPACITY BY			
NH4OAc	(me/100g)	23.1	26.6
EXCHANGEABLE CATIONS BY			
Ca+++	(me/100g)	5.62	6.26
Mg+++	(me/100g)	17.6	19.2
Na+	(me/100g)	1.92	2.44
K+	(me/100g)	0.64	0.69
BASE SATURATION PERCENTAGE		100.	93.0
EXCHANGE ACIDITY BY IN KCl			
TOTAL	(me/100g)	0.41	0.57
H+	(me/100g)	0.09	0.18
AL++	(me/100g)	0.32	0.39
EXTRACTABLE BASES BY IN KCl			
Ca++	(me/100g)	6.37	6.76
Mg++	(me/100g)	17.9	19.2

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

		MY THO	MY THO
DEPTH	(cm)	(0-20)	(20-46)
PARTICLE SIZE	(percent)		
V. COARSE SAND	(2-1mm)	0.00	0.00
COARSE SAND	(1-0.5mm)	0.20	0.10
MEDIUM SAND	(0.5-0.25mm)	0.10	0.10
FINE SAND	(0.25-0.10mm)	0.00	0.10
V. FINE SAND	(0.10-0.05mm)	0.80	0.20
TOTAL SAND	(2-0.05mm)	1.10	0.50
SILT	(0.05-0.002mm)	33.4	38.2
CLAY	(less than 0.002mm)	65.5	61.3
TEXTURAL CLASS(Lab)		C	C
HYDRAULIC CONDUCTIVITY	(cm/hr)		
24th HOUR		-	-
SETTLING VOLUME	(ml)	11.0	12.0
MOISTURE RETENTION	(100Xgm/gm)		
1/10 BAR		53.6	58.7
1/3 BAR		42.8	43.0
15 BAR		24.6	24.3
SOIL REACTION	(pH)		
1:1 H20		5.80	6.40
1:1 1N KCl		4.90	5.50
1:2 0.01 M CaCl2		5.60	6.20
ORGANIC CARBON	(percent)	1.21	0.38
AVAILABLE PHOSPHORUS	(ppm)	10.2	3.90
ACTIVE IRON	(percent)	1.33	2.34
SATURATION EXTRACT	(mmhos/cm)		
SATURATION PERCENTAGE		93.5	114.
ECe @ 25°C		2.23	2.03
SUM OF SOLUBLE BASES	(me/100g)	2.08	2.31
EXCHANGEABLE AL+++	(me/100g)	0.07	0.05
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	5.08	3.58

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

		MY THO	MY THO
<u>CATION EXCHANGE CAPACITY BY</u>			
NH4OAc	(me/100g)	22.7	21.1
<u>EXCHANGEABLE CATIONS BY</u>			
Ca+++	(me/100g)	9,27	8.04
Mg+++	(me/100g)	12,3	12.6
Na+	(me/100g)	2.40	2.62
K+	(me/100g)	0.65	0.72
<u>BASE SATURATION PERCENTAGE</u>		99,3	103.
<u>EXCHANGE ACIDITY BY IN KCl</u>			
TOTAL	(me/100g)	0.03	0.01
H+	(me/100g)	0.03	0.01
AL+++	(me/100g)	0.00	0.00
<u>EXTRACTABLE BASES BY IN KCl</u>			
Ca++	(me/100g)	9.63	8.45
Mg++	(me/100g)	12.8	12.9

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

DEPTH (cm)	PHU VINH (0-18)	PHU VINH (18-41)	PHU VINH (41-53)	PHU VINH (53-76)	PHU VINH (76-107)
PARTICLE SIZE (percent)					
V. COARSE SAND (2-1mm)	0.30	0.70	2.00	0.50	0.30
COARSE SAND (1-0.5mm)	0.60	1.20	5.00	1.00	0.50
MEDIUM SAND (0.5-0.25mm)	1.40	1.30	2.20	1.40	0.40
FINE SAND (0.25-0.10mm)	62.0	54.2	52.2	57.2	42.7
V. FINE SAND (0.10-0.05mm)	15.7	23.8	12.6	14.6	39.0
TOTAL SAND (2-0.05mm)	80.0	81.2	74.0	74.7	82.9
SILT (0.05-0.002mm)	10.5	10.9	8.10	6.70	5.40
CLAY (less than 0.002mm)	9.50	7.90	17.9	18.6	11.7
TEXTURAL CLASS(Lab)	LS/SL	LS	SL	SL	LS/SL
HYDRAULIC CONDUCTIVITY (cm/hr)					
24th HOUR	1.60	6.10	2.00	1.80	2.00
SETTLING VOLUME (ml)	9.00	11.0	14.0	13.0	28.0
MOISTURE RETENTION (100Xgm/gm)					
1/10 BAR	19.0	20.5	40.9	46.8	37.2
1/3 BAR	10.8	7.88	19.8	15.5	11.8
15 BAR	4.50	3.90	7.80	8.60	6.30
SOIL REACTION (pH)					
1:1 H2O	4.60	4.90	4.70	4.70	5.60
1:1 IN KCl	3.90	4.00	3.90	3.70	4.80
1:2 0.01 M CaCl2	4.30	4.50	4.60	4.10	5.40
ORGANIC CARBON (percent)	35.3	4.20	1.90	1.50	0.06
AVAILABLE PHOSPHORUS (ppm)	35.3	4.20	1.90	1.50	0.06
ACTIVE IRON (percent)	0.87	0.69	3.60	3.66	2.10
SATURATION EXTRACT (mmhos/cm)					
SATURATION PERCENTAGE	28.7	28.6	36.1	42.3	33.7
ECe @ 25°C	0.84	0.65	0.73	0.71	0.85
SUM OF SOLUBLE BASES (me/100g)	0.24	0.18	0.26	0.30	0.29
EXCHANGEABLE AL+++ (me/100g)	0.36	0.30	0.42	0.46	0.04
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0 (me/100g)	2.61	1.87	3.21	2.99	1.42

Table C3, Continued

Physical and Chemical Properties of Selected Soil Samples From My Tho Transect

		PHU VINH	PHU VINH	PHU VINH	PHU VINH	PHU VINH
CATION EXCHANGE CAPACITY BY						
NH4OAc	(me/100g)	3.50	3.10	7.50	8.10	5.50
EXCHANGEABLE CATIONS BY						
Ca+++	(me/100g)	1.20	1.07	2.96	3.15	2.42
Mg+++	(me/100g_	0.42	0.41	1.32	1.42	2.20
Na+	(me/100g)	0.20	0.16	0.36	0.34	0.16
K+	(me/100g)	0.05	0.04	0.16	0.19	0.16
BASE SATURATION PERCENTAGE		46.6	48.4	60.5	59.2	84.5
EXCHANGE ACIDITY BY IN KCl						
TOTAL	(me/100g)	0.32	0.25	0.37	0.46	0.01
H+	(me/100g)	0.09	0.06	0.08	0.17	0.01
AL+++	(me/100g)	0.23	0.19	0.29	0.29	0.00
EXTRACTABLE BASES BY IN KCl						
Ca++	(me/100g)	1.35	1.25	3.04	3.19	2.57
Mg++	(me/100g)	0.53	0.53	1.50	1.64	2.36

Table C4

Physical and Chemical Properties of Selected Soil Samples From University of Cantho Campus

DEPTH	(cm)	CAI BE (0-10)	CAI BE (10-20)	CAI BE (20-30)	CAI BE (50-60)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	0.10	0.00	0.10	0.30
COARSE SAND	(1-0.5mm)	0.30	0.30	1.00	1.20
MEDIUM SAND	(0.5-0.25mm)	0.30	0.20	0.70	1.00
FINE SAND	(0.25-0.10mm)	0.90	0.60	1.40	1.70
V. FINE SAND	(0.10-0.05mm)	1.20	0.90	1.50	1.50
TOTAL SAND	(2-0.05mm)	2.80	2.00	4.70	5.70
SILT	(0.05-0.002mm)	47.6	46.0	42.8	45.7
CLAY	(less than 0.002mm)	49.6	52.0	52.5	48.6
TEXTURAL CLASS(Lab)		SiC	SiC	SiC	SiC
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		0.15	0.15	0.60	1.20
SETTLING VOLUME	(ml)	28.0	27.0	20.0	24.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		62.8	60.4	59.6	51.8
1/3 BAR		57.5	51.6	50.0	44.4
15 BAR		31.7	30.4	31.3	26.7
SOIL REACTION	(pH)				
1:1 H2O		4.80	4.70	4.60	4.00
1:1 IN KCl		4.10	3.80	3.80	3.40
1:2 0.01 M CaC12		4.50	4.40	4.40	3.80
ORGANIC CARBON	(percent)	3.17	2.77	4.74	4.98
AVAILABLE PHOSPHORUS	(ppm)	12.3	6.50	4.60	4.30
ACTIVE IRON	(percent)	1.56	1.10	0.87	0.53
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		77.5	78.1	103.	70.6
ECe @ 25°C		1.00	0.81	1.48	2.91
SUM OF SOLUBLE BASES	(me/100g)	0.78	0.63	1.52	2.05
EXCHANGEABLE AL+++	(me/100g)	0.44	0.73	1.11	2.64
TITRATABLE ACIDITY BY BaC12·TEA @ pH 8.0	(me/100g)	8.81	8.88	10.8	13.7

Table C4, Continued

Physical and Chemical Properties of Selected Soil Samples From University of Cantho Campus

		CAI BE	CAI BE	CAI BE	CAI BE
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	20.8	20.0	24.4	26.6
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	8.77	8.55	10.2	14.0
Mg+++	(me/100g)	3.51	3.51	3.83	6.59
Na+	(me/100g)	0.31	0.28	0.28	0.26
K+	(me/100g)	0.21	0.19	0.18	0.21
BASE SATURATION PERCENTAGE		57.8	62.4	58.8	78.4
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	0.70	0.82	0.84	2.95
H+	(me/100g)	0.35	0.29	0.27	1.27
AL+++	(me/100g)	0.35	0.53	0.57	1.68
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	10.0	12.7	10.8	15.8
Mg++	(me/100g)	3.80	3.65	4.02	6.94

Table C4, Continued

Physical and Chemical Properties of Selected Soil Samples
From University of Cantho Campus

DEPTH	(cm)	CAI BE (80-90)	CAI BE (110-120)	CAI BE (140-150)	CAI BE (170-180)
PARTICLE SIZE	(percent)				
V. COARSE SAND	(2-1mm)	4.20	2.00	1.90	0.10
COARSE SAND	(1-0.5mm)	16.0	8.60	10.5	0.20
MEDIUM SAND	(0.5-0.25mm)	10.2	6.50	7.20	0.20
FINE SAND	(0.25-0.10mm)	13.3	9.20	9.00	0.80
V. FINE SAND	(0.10-0.05mm)	7.40	4.80	6.30	1.30
TOTAL SAND	(2-0.05mm)	51.1	31.1	34.9	2.60
SILT	(0.05-0.002mm)	33.2	45.9	44.8	61.2
CLAY	(less than 0.002mm)	15.7	23.0	20.3	36.2
TEXTURAL CLASS(Lab)		L	L	L	SiCl
HYDRAULIC CONDUCTIVITY	(cm/hr)				
24th HOUR		*NES	1.10	1.00	0.35
SETTLING VOLUME	(ml)	22.0	22.0	23.0	29.0
MOISTURE RETENTION	(100Xgm/gm)				
1/10 BAR		67.1	52.0	54.6	59.6
1/3 BAR		56.0	43.4	43.7	46.4
15 BAR		30.5	23.8	24.6	25.2
SOIL REACTION	(pH)				
1:1 H2O		3.70	2.90	2.80	3.40
1:1 IN KCl		3.30	2.30	2.40	3.20
1:2 0.01 M CaCl2		3.50	2.60	2.50	3.30
ORGANIC CARBON	(percent)	22.5	7.46	7.59	2.28
AVAILABLE PHOSPHORUS	(ppm)	1.80	9.20	14.2	17.4
ACTIVE IRON	(percent)	1.75	1.98	2.34	1.50
SATURATION EXTRACT	(mmhos/cm)				
SATURATION PERCENTAGE		69.5	62.3	61.5	76.2
ECe @ 25°C		7.23	26.9	28.1	10.4
SUM OF SOLUBLE BASES	(me/100g)	5.02	16.8	17.3	7.92
EXCHANGEABLE AL+++	(me/100g)	5.09	17.0	15.8	5.80
TITRATABLE ACIDITY BY BaCl2·TEA @ pH 8.0	(me/100g)	25.8	29.4	29.2	15.0

Table C4, Continued

Physical and Chemical Properties of Selected Soil Samples
From University of Cantho Campus

		CAI BE	CAI BE	CAI BE	CAI BE
CATION EXCHANGE CAPACITY BY					
NH4OAc	(me/100g)	80.3	28.0	31.7	19.5
EXCHANGEABLE CATIONS BY					
Ca+++	(me/100g)	38.3	13.6	13.6	11.5
Mg+++	(me/100g)	26.8	19.8	22.5	18.8
Na+	(me/100g)	0.40	0.13	0.10	0.16
K+	(me/100)	0.07	0.08	0.07	0.23
BASE SATURATION PERCENTAGE		75.4	54.0	59.8	117.
EXCHANGE ACIDITY BY IN KCl					
TOTAL	(me/100g)	5.51	34.7	39.9	7.10
H+	(me/100g)	3.02	20.5	25.7	4.41
AL+++	(me/100g)	2.49	14.2	14.2	2.69
EXTRACTABLE BASES BY IN KCl					
Ca++	(me/100g)	43.5	13.6	14.4	12.3
Mg++	(me/100g)	27.3	19.8	23.1	19.1

APPENDIX D

Table D1

Moisture Release Data

CAI SAN (0-15)		CAI SAN (15-30)		CAI SAN (30-46)		CAI SAN (0-10)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.5776	0.000	.5687	0.000	.5619	0.000	.5845	0.000
.5689	16.32	.5621	16.32	.5421	16.32	.5706	12.24
.5667	48.96	.5628	48.96	.5150	48.96	.5647	48.96
.5630	99.28	.5291	99.28	.5084	99.28	.5464	103.4
.5601	152.3	.5225	152.3	.5047	152.3	.5405	205.4
.5014	331.8	.5035	331.8	.4937	331.8	.5317	331.8
.4904	451.5	.4940	451.5	.4871	451.5	.5251	448.8
.4772	654.2	.4815	654.2	.4784	654.2	.5178	658.2
.4669	820.1	.4690	820.1	.4711	820.1	.5127	825.5
.4544	998.2	.4602	998.2	.4638	998.2	.5046	1008.
.3715	15000	.3833	15000	.3393	15000	.3764	15000
BULK DENSITY							
1.172		1.282		1.290		1.180	

Table D1, Continued

Moisture Release Data

CAI SAN (0-15)		CAI SAN (15-30)		CAI SAN (30-46)		CAI SAN (0-10)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.5386	0.000	.5974	0.000	.5749	0.000	.4988	0.000
.5334	12.24	.5710	12.24	.5331	12.24	.4856	12.24
.5298	48.96	.5556	48.96	.5141	48.96	.4541	51.68
.5181	103.4	.5329	103.4	.4906	103.4	.4461	100.6
.5137	205.4	.5255	205.4	.4818	205.4	.4351	199.9
.5063	331.8	.5167	331.8	.4715	331.8	.4255	331.8
.4990	448.8	.5087	448.8	.4613	448.8	.4189	451.5
.4902	658.2	.4984	658.2	.4547	658.2	.4094	650.1
.4807	825.5	.4889	825.5	.4437	825.5	.4013	825.5
.4704	1008.	.4786	1008.	.4312	1008.	.3940	999.6
.3305	15000	.3274	15000	.2899	15000	.2113	15000

BULK DENSITY

1.107	1.084	1.218	1.418

Table D1, Continued

Moisture Release Data

LONG XUYEN (15-28)		LONG XUYEN (28-46)		CAI BE (0-28)		CAI BE (28-46)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.4383	0.000	.4420	0.000	.5577	0.000	.5236	0.000
.4207	12.24	.4332	12.24	.5526	12.24	.5207	12.24
.3988	51.68	.4104	51.68	.5489	51.68	.5185	51.68
.3951	100.6	.3995	100.6	.5401	100.6	.5200	100.6
.3870	199.9	.3855	199.9	.5357	199.9	.5200	199.9
.3797	331.8	.3753	331.8	.5306	331.8	.5192	331.8
.3753	451.5	.3679	451.5	.5262	451.5	.5192	451.5
.3680	650.1	.3599	650.1	.5196	650.1	.5185	650.1
.3614	825.3	.3533	825.3	.5137	825.3	.5097	825.3
.3555	999.6	.3473	999.6	.5071	999.6	.4965	999.6
.4208	15000	.2711	15000	.3417	15000	.3528	15000

BULK DENSITY

LONG XUYEN (15-28)	LONG XUYEN (28-46)	CAI BE (0-28)	CAI BE (28-46)
1.5050	1.4898	1.1661	1.2784

Table D1, Continued

Moisture Release Data

CAI LAY (0-15)		CAI LAY (15-28)		CAI LAY (28-51)		LONG MY (0-10)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.5177	0.000	.4687	0.000	.5009	0.000	.5483	0.000
.5030	12.24	.4592	12.24	.4965	12.24	.5366	12.24
.4993	51.68	.4526	51.68	.4775	51.68	.5029	51.68
.5014	100.6	.4525	100.6	.4694	100.6	.4941	100.6
.4978	199.9	.4437	199.9	.4452	199.9	.4838	197.2
.4941	331.8	.4363	331.8	.4357	331.8	.4750	331.8
.4912	451.5	.4312	451.5	.4254	451.5	.4684	451.5
.4860	650.1	.4253	650.1	.4174	652.8	.4589	652.8
.4794	825.3	.4180	825.3	.4078	826.9	.4523	825.3
.4743	999.6	.4114	999.6	.3983	999.6	.4435	999.6
.3398	15000	.3190	15000	.3056	15000	.3194	15000

BULK DENSITY

CAI LAY (0-15)	CAI LAY (15-28)	CAI LAY (28-51)	LONG MY (0-10)
1.1558	1.3811	1.268	1.309

Table D1, Continued

Moisture Release Data

LONG MY (10-25)		LONG MY (25-41)		LONG MY (41-51)		LONG XUYEN (15-30)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.4940	0.000	.6009	0.000	.4867	0.000	.4303	0.000
.4911	12.24	.5929	12.24	.4838	12.24	.4259	12.24
.4911	51.68	.5775	51.68	.4831	51.68	.4259	51.68
.4794	100.6	.5612	100.6	.4802	100.6	.4252	100.6
.4728	199.9	.5364	199.9	.4618	199.9	.4245	199.9
.4669	331.8	.5247	331.8	.4530	331.8	.4245	331.8
.4581	451.5	.5166	451.5	.4450	451.5	.4245	451.5
.4500	652.8	.5056	652.8	.4354	652.8	.4237	652.8
.4427	826.9	.4961	826.9	.4259	826.9	.4230	826.9
.4368	999.6	.4851	999.6	.4193	999.6	.4230	999.6
.3414	15000	.2384	15000	.2968	15000	.4325	15000
BULK DENSITY							
1.371		1.198		1.400		1.670	

Table D1, Continued

Moisture Release Data

LONG XUYEN (30-48)		CAI LAY (0-18)		CAI LAY (18-36)		CAI LAY (36-53)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.4454	0.000	.4391	0.000	.5057	0.000	.5512	0.000
.4447	12.24	.4340	12.24	.5049	12.24	.5512	12.24
.4447	51.68	.4340	51.68	.5042	51.68	.5512	51.68
.4447	100.6	.4340	100.6	.5035	100.6	.5512	100.6
.4447	199.9	.4340	199.9	.4925	197.2	.5373	197.2
.4381	331.8	.4333	331.8	.4866	331.8	.5314	331.8
.4337	451.5	.4303	451.5	.4815	451.5	.5263	451.5
.4278	652.8	.4296	652.8	.4720	652.8	.5175	652.8
.4219	826.9	.4289	826.9	.4646	825.3	.5058	825.3
.4168	999.6	.4296	999.6	.4551	999.6	.4867	999.6
.3584	15000	.4389	15000	.3697	15000	.3339	15000
BULK DENSITY							
1.538		1.644		1.433		1.246	

Table D1, Continued

Moisture Release Data

MY THO (0-20)		MY THO (20-46)		PHU VINH (18-41)		PHU VINH (41-53)		PHU VINH (53-76)	
THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)	THETA (cm^3/cm^3)	TENSION (cm)
.4287	0.000	.5329	0.000	.3499	0.000	.3845	0.000	.4615	0.000
.4257	12.25	.5094	12.25	.3455	12.25	.3632	12.25	.4358	12.25
.4257	51.68	.5065	51.68	.2648	51.68	.3119	51.68	.4131	51.68
.4250	100.6	.5043	100.6	.1915	100.6	.2929	100.6	.4051	100.6
.4243	197.2	.4904	197.2	.1607	197.2	.2789	197.2	.3970	197.2
.4243	331.8	.4838	331.8	.1468	331.8	.2731	331.8	.3911	331.8
.4250	451.5	.4779	451.5	.1395	451.5	.2709	451.5	.3853	451.5
.4250	652.8	.4698	652.8	.1321	652.8	.2679	652.8	.3765	652.8
.4250	825.3	.4618	825.3	.1277	825.3	.2657	825.3	.3684	825.3
.4228	999.6	.4515	999.6	.1226	999.6	.2606	999.6	.3574	999.6
.3953	15000	.3830	15000	.0649	15000	.3141	15000	.1404	15000
BULK DENSITY									
1.607		1.339		1.663		1.719		1.632	

APPENDIX E

Table E1

Soil Water Conductivity Data

Soil	Conductivity (cm/min)	Theta (cm^3/cm^3)	Tension (cm)
CAI SAN (0-15)	1.67 X 10^{-03}	.5776	1.00 X 10^{0}
	1.02 X 10^{-06}	.5482	4.50 X 10^{1}
	7.80 X 10^{-08}	.5187	1.80 X 10^{2}
	1.10 X 10^{-08}	.4893	5.10 X 10^{2}
	1.90 X 10^{-09}	.4598	1.23 X 10^{3}
	3.12 X 10^{-10}	.4304	2.85 X 10^{3}
	3.55 X 10^{-11}	.4009	6.85 X 10^{3}
	7.41 X 10^{-12}	.3715	1.50 X 10^{4}
(15-30)	8.30 X 10^{-04}	.5687	1.00 X 10^{0}
	6.21 X 10^{-06}	.5422	1.15 X 10^{1}
	2.99 X 10^{-08}	.5157	2.10 X 10^{2}
	4.77 X 10^{-09}	.4892	5.40 X 10^{2}
	8.24 X 10^{-10}	.4628	1.30 X 10^{3}
	1.39 X 10^{-10}	.4364	3.10 X 10^{3}
	1.81 X 10^{-11}	.4098	6.70 X 10^{3}
	3.61 X 10^{-12}	.3833	1.50 X 10^{4}
(30-46)	8.30 X 10^{-04}	.5619	1.00 X 10^{0}
	1.61 X 10^{-06}	.5301	2.30 X 10^{1}
	1.82 X 10^{-08}	.4983	2.40 X 10^{2}
	1.66 X 10^{-09}	.4665	9.80 X 10^{2}
	3.53 X 10^{-10}	.4347	2.20 X 10^{3}
	7.67 X 10^{-11}	.4029	4.50 X 10^{3}
	1.20 X 10^{-11}	.3711	8.30 X 10^{3}
	3.67 X 10^{-12}	.3393	1.50 X 10^{4}
CAI BE (0-10)	8.30 X 10^{-04}	.5845	1.00 X 10^{0}
	7.76 X 10^{-07}	.5548	3.30 x 10^{1}
	6.58 X 10^{-09}	.5250	4.50 X 10^{2}
	1.12 X 10^{-09}	.4953	1.25 X 10^{3}
	2.67 X 10^{-10}	.4656	2.65 X 10^{3}
	6.39 X 10^{-11}	.4359	5.10 X 10^{3}
	1.-7 X 10^{-11}	.4061	8.80 X 10^{3}
	3.69 X 10^{-12}	.3764	1.50 X 10^{4}
(10-28)	1.83 X 10^{-03}	.5386	1.00 X 10^{0}
	3.03 X 10^{-08}	.5089	3.15 X 10^{2}
	5.72 X 10^{-09}	.4791	9.20 X 10^{2}
	1.79 X 10^{-09}	.4494	1.80 X 10^{3}
	5.88 X 10^{-10}	.4196	2.95 X 10^{3}
	1.63 X 10^{-10}	.3900	4.80 X 10^{3}
	2.79 X 10^{-11}	.3602	8.10 X 10^{3}
	8.13 X 10^{-12}	.3305	1.50 X 10^{4}

Table E1, Continued

Soil Water Conductivity Data

SOIL	CONDUCTIVITY (cm/min)	THETA (cm^3/cm^3)	TENSION (cm)
CAI BE (28-36)	8.30×10^{-04}	.5974	1.00×10^{0}
	7.16×10^{-05}	.5588	3.00×10^{0}
	9.59×10^{-07}	.5203	2.60×10^{1}
	1.62×10^{-08}	.4817	2.20×10^{2}
	1.40×10^{-09}	.4431	8.80×10^{2}
	2.35×10^{-10}	.4045	2.00×10^{3}
	2.69×10^{-11}	.3660	4.80×10^{3}
	2.75×10^{-12}	.3274	1.50×10^{4}
(36-64)	8.30×10^{-04}	.5749	1.00×10^{0}
	7.61×10^{-08}	.5342	1.10×10^{2}
	3.34×10^{-09}	.4935	7.10×10^{2}
	8.15×10^{-10}	.4528	1.65×10^{3}
	2.41×10^{-10}	.4120	3.00×10^{3}
	6.37×10^{-11}	.3713	5.10×10^{3}
	1.06×10^{-11}	.3306	8.85×10^{3}
	3.69×10^{-12}	.2899	1.50×10^{4}
LONG XUYEN (0-15)	3.33×10^{-03}	.4988	1.00×10^{0}
	8.75×10^{-07}	.4577	6.40×10^{1}
	2.48×10^{-08}	.4167	4.50×10^{2}
	3.84×10^{-09}	.3756	1.40×10^{3}
	9.94×10^{-10}	.3345	2.85×10^{3}
	2.52×10^{-10}	.2934	5.20×10^{3}
	4.30×10^{-11}	.2524	8.80×10^{3}
	1.48×10^{-11}	.2113	1.50×10^{4}
(15-28)	2.50×10^{-03}	.4383	1.00×10^{0}
	1.58×10^{-06}	.4183	4.00×10^{1}
	9.27×10^{-09}	.3819	3.00×10^{3}
	3.87×10^{-09}	.3537	1.10×10^{3}
	8.15×10^{-10}	.3254	2.60×10^{3}
	1.90×10^{-10}	.2972	5.10×10^{3}
	3.15×10^{-11}	.2690	8.90×10^{3}
	1.11×10^{-11}	.2408	1.50×10^{4}
(28-46)	3.33×10^{-03}	.4420	1.00×10^{0}
	2.34×10^{-05}	.4176	4.30×10^{1}
	2.10×10^{-07}	.3932	1.50×10^{2}
	2.57×10^{-08}	.3688	4.70×10^{2}
	4.45×10^{-09}	.3443	1.15×10^{3}
	7.68×10^{-10}	.3199	2.60×10^{3}
	9.23×10^{-11}	.2955	6.00×10^{3}
	1.48×10^{-11}	.2711	1.50×10^{4}

Table E1, Continued

Soil Water Conductivity Data

Soil	Conductivity (cm/min)	Theta (cm^3/cm^3)	Tension (cm)
CAI BE (0-28)	8.30×10^{-04}	.5577	1.00×10^{0}
	8.35×10^{-09}	.5268	3.90×10^{2}
	1.43×10^{-09}	.4960	1.27×10^{3}
	4.64×10^{-10}	.4651	2.40×10^{3}
	1.58×10^{-10}	.4343	4.00×10^{3}
	4.73×10^{-11}	.4034	6.40×10^{3}
	9.01×10^{-12}	.3726	9.60×10^{3}
	3.69×10^{-12}	.3417	1.50×10^{4}
(28-46)	8.30×10^{-04}	.5236	1.00×10^{0}
	2.88×10^{-09}	.4992	9.20×10^{2}
	9.91×10^{-10}	.4748	1.70×10^{3}
	3.68×10^{-10}	.4504	2.85×10^{3}
	1.34×10^{-10}	.4260	4.55×10^{3}
	4.34×10^{-11}	.4016	6.90×10^{3}
	8.30×10^{-12}	.3772	1.00×10^{3}
	3.69×10^{-12}	.3528	1.50×10^{4}
CAI LAY (0-15)	4.17×10^{-03}	.5177	1.00×10^{0}
	2.95×10^{-08}	.4923	5.00×10^{2}
	6.29×10^{-09}	.4669	1.35×10^{3}
	2.05×10^{-09}	.4415	2.60×10^{3}
	7.13×10^{-19}	.4160	4.30×10^{3}
	2.18×10^{-10}	.3906	6.70×10^{3}
	4.17×10^{-11}	.3652	1.00×10^{4}
	1.85×10^{-11}	.3398	1.50×10^{4}
(15-28)	8.30×10^{-04}	.4687	1.00×10^{0}
	3.58×10^{-08}	.4473	1.80×10^{2}
	4.54×10^{-09}	.4259	6.20×10^{2}
	1.08×10^{-09}	.4045	1.30×10^{3}
	2.70×10^{-10}	.3832	2.70×10^{3}
	6.60×10^{-11}	.3618	4.90×10^{3}
	1.05×10^{-11}	.3404	8.90×10^{3}
	3.69×10^{-12}	.3190	1.50×10^{4}
(28-51)	8.30×10^{-04}	.5009	1.00×10^{0}
	2.05×10^{-07}	.4730	7.20×10^{1}
	2.00×10^{-08}	.4451	2.95×10^{2}
	4.50×10^{-09}	.4172	5.90×10^{2}
	8.94×10^{-10}	.3893	1.30×10^{3}
	1.63×10^{-10}	.3614	2.90×10^{3}
	2.16×10^{-11}	.3335	6.20×10^{3}
	3.69×10^{-12}	.3056	1.50×10^{4}

Table E1, Continued

Soil Water Conductivity Data

Soil	Conductivity (cm/min)	Theta (cm^3/cm^3)	Tension (cm)
LONG MY (0-10)	$8.30 \text{ X } 10^{-04}$	.5483	$1.00 \text{ X } 10^{0}$
	$8.71 \text{ X } 10^{-07}$	.5156	$3.20 \text{ X } 10^{1}$
	$2.33 \text{ X } 10^{-08}$	.4829	$2.10 \text{ X } 10^{2}$
	$1.89 \text{ X } 10^{-09}$	.4502	$8.70 \text{ X } 10^{2}$
	$3.59 \text{ X } 10^{-10}$	.4175	$2.25 \text{ X } 10^{3}$
	$8.18 \text{ X } 10^{-11}$	.3848	$4.30 \text{ X } 10^{3}$
	$1.23 \text{ X } 10^{-11}$	.3521	$8.20 \text{ X } 10^{3}$
	$3.68 \text{ X } 10^{-12}$	.3194	$1.50 \text{ X } 10^{4}$
(10-25)	$1.67 \text{ X } 10^{-03}$	.4940	$1.00 \text{ X } 10^{0}$
	$7.52 \text{ X } 10^{-08}$	.4722	$1.80 \text{ X } 10^{2}$
	$1.07 \text{ X } 10^{-08}$	.4504	$5.80 \text{ X } 10^{2}$
	$2.60 \text{ X } 10^{-09}$	.4286	$1.20 \text{ X } 10^{3}$
	$6.50 \text{ X } 10^{-10}$	.4068	$2.40 \text{ X } 10^{3}$
	$1.53 \text{ X } 10^{-10}$	.3850	$4.60 \text{ X } 10^{3}$
	$2.48 \text{ X } 10^{-11}$	.3632	$8.20 \text{ X } 10^{3}$
	$7.42 \text{ X } 10^{-12}$	.3414	$1.50 \text{ X } 10^{4}$
(25-41)	$1.67 \text{ X } 10^{-03}$	.6009	$1.00 \text{ X } 10^{0}$
	$8.09 \text{ X } 10^{-08}$	.5491	$1.60 \text{ X } 10^{2}$
	$6.35 \text{ X } 10^{-09}$	.4973	$6.40 \text{ X } 10^{2}$
	$1.07 \text{ X } 10^{-09}$	.4455	$1.95 \text{ X } 10^{3}$
	$3.00 \text{ X } 10^{-10}$	.3938	$3.85 \text{ X } 10^{3}$
	$8.26 \text{ X } 10^{-11}$	.3420	$6.70 \text{ X } 10^{3}$
	$1.52 \text{ X } 10^{-11}$	.2902	$1.05 \text{ X } 10^{4}$
	$7.42 \text{ X } 10^{-12}$	.2384	$1.50 \text{ X } 10^{4}$
(41-51)	$8.30 \text{ X } 10^{-04}$	.4867	$1.00 \text{ X } 10^{0}$
	$2.40 \text{ X } 10^{-08}$	.4596	$2.30 \text{ X } 10^{2}$
	$3.51 \text{ X } 10^{-09}$	.4324	$6.50 \text{ X } 10^{2}$
	$7.21 \text{ X } 10^{-10}$	.4053	$1.65 \text{ X } 10^{3}$
	$2.00 \text{ X } 10^{-10}$	.3782	$3.40 \text{ X } 10^{3}$
	$5.59 \text{ X } 10^{-11}$	.3511	$5.60 \text{ X } 10^{3}$
	$9.81 \text{ X } 10^{-12}$	.3239	$9.20 \text{ X } 10^{3}$
	$3.69 \text{ X } 10^{-12}$	.2968	$1.50 \text{ X } 10^{4}$
PHU VINH (18-41)	$1.02 \text{ X } 10^{-02}$	.3499	$1.00 \text{ X } 10^{0}$
	$3.78 \text{ X } 10^{-05}$	.3092	$3.10 \text{ X } 10^{1}$
	$1.38 \text{ X } 10^{-05}$	.2685	$5.00 \text{ X } 10^{1}$
	$4.42 \text{ X } 10^{-06}$	.2278	$7.30 \text{ X } 10^{1}$
	$9.59 \text{ X } 10^{-07}$	.1870	$1.20 \text{ X } 10^{2}$
	$8.87 \text{ X } 10^{-08}$	.1463	$3.50 \text{ X } 10^{2}$
	$2.09 \text{ X } 10^{-09}$	.1056	$2.20 \text{ X } 10^{3}$
	$4.49 \text{ X } 10^{-11}$	.0649	$1.50 \text{ X } 10^{4}$

Table E1, Continued

Soil Water Conductivity Data

Soil	Conductivity (cm/min)	Theta (cm^3/cm^3)	Tension (cm)
PHU VINH (41-53)	3.67×10^{-02}	,3845	1.00×10^{0}
	1.24×10^{-04}	,3487	$2,10 \times 10^{1}$
	1.48×10^{-05}	,3130	5.40×10^{1}
	$7,89 \times 10^{-07}$	.2772	$2,20 \times 10^{2}$
	$1,59 \times 10^{-08}$	,2414	$2,05 \times 10^{3}$
	$3,05 \times 10^{-09}$	,2056	4.75×10^{3}
	4.80×10^{-10}	,1699	8.70×10^{3}
	$1,62 \times 10^{-10}$	,1341	1.50×10^{4}
(53-76)	3.00×10^{-02}	,4615	1.00×10^{0}
	1.13×10^{-05}	.4156	5.20×10^{1}
	1.13×10^{-07}	.3698	7.20×10^{2}
	$2,64 \times 10^{-08}$	.3239	$1,70 \times 10^{3}$
	7.62×10^{-09}	,2780	3.25×10^{3}
	$2,05 \times 10^{-09}$	,2321	5.40×10^{3}
	3.39×10^{-10}	.1863	9.40×10^{4}
	$1,33 \times 10^{-10}$	.1404	1.50×10^{4}