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BANGLADESH AGRICULTURAL RESEARCH PROJECT PHASE-II

CLAY MINERALOGY OF SOME SOILS OF BANGLADESH

Joe L. White

BANGLADESH AGRICULTURAL RESEARCH COUNCIL
INTERNATIONAL AGRICULTURAL DEVELOPMENT SERVICE
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CLAY MINERALOGY OF SOME SOILS OF BANGLADESH

A

Consultancy Report

by

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April, 1985

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(IADS/BARC)

TABLE OF CONTENTS

The Author	i
Acknowledgements	ii
Summary Report	iii
Introduction	1
Terms of Reference	1
Summary of Activities and Results	1
Recommendations for the Future	7
Appendix - I — Bangladesh Soil Mineralogy Analyses Study for IADS/BARC.	
Appendix - II — A Summary of Chemical and Clay Mineral Composition and Responses to Potassium Applications for Thirty Two Locations Sampled by BARI.	
Appendix -III — Location, Description and Chemical Analyses of Samples from 18 Sites at Different Depth Collected by SRDI.	
Appendix - IV — A Summary of Activities and Persons Visited During Consultancy.	

THE AUTHOR:

Dr. Joe L. White is a native of Oklahoma and earned B.S. and M.S. degrees in soil science at Oklahoma State University, Stillwater, Oklahoma, in 1944 and 1945, respectively. He received a Ph.D. in soil chemistry and mineralogy at the University of Wisconsin, Madison, Wisconsin, in 1947. He accepted a position as Assistant Professor of Agronomy at Purdue University in 1947 and is currently Professor of Agronomy there. His research and teaching experience includes extensive work in the following areas: (1) X-ray diffraction studies of the weathering of micaceous minerals, (2) surface chemistry studies of soil-pesticide interactions, (3) structure and properties of aluminum hydroxide gels, and (4) mineralogical applications of infrared spectroscopy. He has published over 130 referred papers in these areas.

Dr. White has spent sabbatical periods in Britain, Belgium, France, Greece, and West Germany. He has also participated in the National Academy of Science Exchange Programs with Poland, Yugoslavia, and Romania. He has served as consultant to engineering and pharmaceutical firms on mineralogical analysis of soils and clay minerals from Costa Rica, Saudia Arabia, Japan, and South Korea. He has served as advisor for graduate students who have made mineralogical studies of soils from Colombia, Brazil, and the Philippines.

Dr. White is a member of the Soil Science Society of America, the American Society of Agronomy, the Clay Minerals Society, Groupe Argile Francais, Mineralogical Society of America, Mineralogical Society (GB), American Chemical Society, American Institute of Chemists, the Royal Chemical Society, and the International Society of Soil Science.

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I am especially grateful to Dr. Sam Portch, IADS Soil Scientist, for organizing my visit and arranging for meetings and conferences with Bangladesh scientists to maximize the value of my consultancy.

The generosity of Dr. Z. Karim (BARI) and Mr. S.M. Saheed (SRDI) in setting aside many hours for extended discussions on the relationships between parent materials and clay mineralogy of Bangladesh soils is gratefully acknowledged. Dr. M.S. Islam (BARI) kindly provided chemical and crop response data for a considerable number of soil samples.

The support and encouragement of BARC Member-Director (Soils) Dr. Omar Ali, BARI Director, Dr. Motlubur Rahman, BRRI Director Dr. M.A. Mannan, and their respective staffs was very helpful.

SUMMARY REPORT

By

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Soil Mineralogy Consultant
April 16-30, 1985

This consultancy was initiated through IADS/BARC (Dr. Sam Portch and Dr. M.A. Mannan) who arranged for the analysis of 115 samples of soil from Bangladesh. The agreement called for qualitative analysis of the clay mineral fraction of the soil samples. The clay fractions (less than 2 microns) were obtained by sedimentation after a brief ultrasonic treatment to disperse the soils. Oriented specimens were prepared as films on glass slides and diffractograms recorded on a General Electric XRD-5 X-Ray diffractometer in the Department of Agronomy, Purdue University, West Lafayette, IN 47907. In addition to diffractograms of untreated specimens of all 115 samples, an additional 56 diffractograms were made of selected samples which had been heated to 500 degrees C. or solvated with ethylene glycol in order to properly identify and distinguish between possible vermiculite, chlorite, and smectite (montmorillonite) phases. Qualitative estimates of the composition were made on the basis of parts per ten for all 115 samples and the analyses prepared in table form. In addition, three copies of the tabulated results and sets of the 171 diffractograms were delivered to 1. Dr. Sam Portch (IADS), 2. Dr. Z. Karim (BARI), and 3. Mr. S.M. Saheed (SRDI); in addition, one copy was sent to IADS in Arlington, VA. Additional copies are located at the libraries of BARI,BRRI, BARC, and BAU.

Extensive discussions were held on a daily basis with Dr. Z. Karim, Mr. S.M. Saheed, and Dr. Sam Portch, in plotting the precise locations of the sample sites and collecting comprehensive data on parent material, chemical and physical

properties, and crop response data, where available. Dr. M.S. Islam(BARI) also provided valuable assistance in supplying chemical and crop response data. As a result of the extended discussions and conferences it was possible to determine specific patterns of mineralogical composition as related to parent materials and drainage conditions.

Most of the parent material is of alluvial origin; it appears that the dominant parent material in the clay fraction is muscovite mica, along with moderate amounts of kaolinite. The mica is weathered to vermiculite under acidic conditions and under basic conditions it weathers to smectite or montmorillonite. Under acidic conditions aluminum polymers resulting from dissolution and decomposition of the mineral phases may be exchanged onto the expanded mica or vermiculite; this may reduce the capacity of the weathered micaceous clay to "fix" potassium.

X-Ray diffractograms show the presence of amorphous material in some of the highly weathered soils; this was confirmed by chemical data on oxalate-extractable aluminum. The 001/002 intensity ratio for mica suggests that only the resistant core of the muscovite mica remains where "ferrolysis" has occurred. The amorphous material could be involved in phosphorous fixation.

Some mica materials have been weathered to a "high charge" vermiculite; this would have the capacity to fix large amounts of potassium. This appears to be true for the BAU Mymensingh samples from the potash experiments. Management practices which localize potassium fertilizer application would minimize possible fixation problems. Soils having an 001/002 intensity ratio for mica around 2.0 have been intensely weathered and only the resistant core of the mica is left. Such soils are likely to show response to potassium fertilization.

RECOMMENDATIONS FOR THE FUTURE:

This qualitative overview provides a basis for understanding the mineralogy that is typical for the main parent materials and specific weathering factors. A more detailed mineralogical study is recommended for the near future; the relationships and trends established in this present collaborative effort will make it possible to choose sample sites which reflect the range of physical and chemical properties characteristic of a given soil mapping unit. Information on the separation and preparation of clay fractions of soils was presented in the Workshop on Soil Mineralogy on April 28 that will make it possible for the soil scientists here to minimize the cost of having X-ray diffractograms recorded by laboratories in or outside this country. Glass slides having oriented films of the soil clay fractions could be prepared by scientists here and shipped to other laboratories for analysis.

Utilization of soil mineralogy data will aid in recognizing soils that may require special management practices that utilize fertilizer more efficiently.

REPORT TO BANGLADESH AGRICULTURE RESEARCH COUNCIL (BARC)

ON

CLAY MINERALOGY OF SOME SOILS OF BANGLADESH

1.0 INTRODUCTION:

This consultancy on soil mineralogy was for a period of two weeks in Bangladesh. This was preceded by the preparation and X-ray diffraction analysis of 115 Bangladesh soil samples in the laboratories of the Purdue University, Department of Agronomy, West Lafayette, Indiana, USA under a contract with IADS in Arlington, VA. The following are the terms of reference for this consultancy.

2.0 TERMS OF REFERENCE:

2.1 To discuss with national Soil Scientists the interpretations and findings from soil mineralogical analyses (X-ray diffraction) done by the consultant in the U.S.

2.2 To discuss with SRDI personnel the implications of mineralogical findings and soil survey maps produced by them.

2.3 To present a seminar on the practical use of soil mineralogical data for agricultural land use.

2.4 To participate in a two day workshop on interpretation of X-ray diffraction data of Bangladesh soils.

3.0 SUMMARY OF ACTIVITIES AND RESULTS:

This consultancy in soil mineralogy was initiated through IADS/BARC (Dr. Sam Portch and Dr. M.A. Mannan) who arranged for the X-ray

diffraction analysis of the clay fractions of 115 Bangladesh soil samples. The agreement specified that the analyses would be qualitative in nature.

The clay fractions (less than 2 microns) were obtained by a dispersion process in which the pH of the suspension (10 g. clay in 120 ml. distilled water) was adjusted to approximately 9 with sodium carbonate and then treated with an ultrasonic microprobe operating at a power setting of 80 watts for 1 minute. After a sedimentation time of 3 hrs. 30 minutes the upper 5 cm. of the suspension was removed; this provided a sample having a particle size less than 2 microns.

Oriented specimens were prepared as films on glass slides by adding about 2 ml. of the clay fraction to a 1 x 3 inch glass slide resting on a perfectly level surface. The suspension was then spread to cover the center 2 inches of the glass slide and allowed to air-dry.

X-ray diffraction patterns were recorded out to 30 degrees 2θ (just past the 3.33 A. peak of mica) on a General Electric XRD-5 X-ray Diffractometer in the Department of Agronomy, Purdue University, West Lafayette, IN, 47907, USA. In addition to recording diffractograms of untreated specimens of all 115 samples, an additional 56 diffractograms (giving a total of 171) were made of selected samples which had been either heated to 500 degrees C. for 3 hrs., or solvated with ethylene glycol. These treatments were deemed necessary in order to properly identify and distinguish between the possible presence of vermiculite, chlorite, and smectite (montmorillonite) phases. Qualitative estimates of the clay mineral composition were made on the basis of parts per ten for all 115 samples and the data arranged in table form (Appendix I).

In addition, three copies of the tabulated results and complete sets of the 171 diffractograms were delivered to (1) Dr. Sam Portch (IADS), (2) Dr. Z. Karim (BARI), and (3) Mr. S.M. Saheed; one copy was also sent to IADS in Arlington, VA. Additional copies are available at the libraries of BARC, BARI, BRRI, and BAU.

Extensive discussions and consultations were held on an almost daily basis with Dr. Z. Karim (BARI), Mr. S.M. Saheed (SRDI), and Dr. Sam Portch (IADS), in order to accurately determine the locations of the sample sites and to collect and compile comprehensive data on parent materials, chemical and physical properties, and crop response data, where available (see Appendix IV). Dr. M.S. Islam (BARI) provided valuable chemical and crop response data for many of the samples. As a result of the extended discussions and conference, it was possible for us to determine specific patterns of mineralogical composition as related to parent materials and drainage conditions. Available soil chemcial and clay mineral composition and responses to potassium application for 32 samples from BARI are summarized in Appendix II. Data for 18 sites sampled at different depths by SRDI are given in Appendix III.

Most of the parent materials are of alluvial origin; it appears that the dominant parent material of the clay fraction is muscovite mica, along with moderate amounts of kaolinite. The mica appears to be weathered to vermiculite under moderately acidic conditions; under these conditions aluminum hydroxy polymers, which result from the dissolution and decomposition of the mineral phases, may be exchanged onto the expanded mica or vermiculite. This may reduce the capacity of the weathered micaceous minerals to fix potassium. If the pH of soils containing significant amounts of interlayer aluminum hydroxy polymers is raised above a pH of 6.5, there is a possibility that the aluminum polymers will be neutralized and expelled into the soil solution. This

produces high surface aluminum hydroxide which is capable of fixing large amounts of phosphorus. The activity of aluminum on the surface of the freshly precipitated aluminum hydroxide may be sufficiently high to produce aluminum toxicity in sensitive crops.

Under neutral or basic conditions in soils that are poorly drained, the mica weathers to smectite (montmorillonite); such weathering trends are characteristic in the Ganges River alluvium group of soils.

In order to better understand the nature of the mica weathering sequence in Bangladesh soils, I have utilized the concept of a mica "weathering index" to estimate the extent to which potassium has been removed from the 10 A. mica components in soil clays. The ratio of the intensities of the 10 A. (001 d-spacing) and 5 A. (002 d-spacing) diffraction peaks of mica is a direct function of the amount of potassium in the interlayer sites in the mica structure. Thus, a muscovite mica with a full complement of potassium will have an 001/002 ratio of about 2. If approximately one-half of the potassium has been removed by weathering, the 001/002 ratio will be around 5 to 6.

It appears that under extremely intense weathering conditions a process designated as "ferrolysis" by Dr. Robert Brinkman, can become a dominant factor in the weathering trend. The process of "ferrolysis" is characterized by alternating cycles of oxidation and reduction of iron. Extremely low pH values are produced and all but the most resistant muscovite mica particles are destroyed. It is suggested that the highly resistant muscovite mica, which has an 001/002 ratio of about 2, would have a relatively low "potassium-supplying power"; soils which

contain this form of mica as the only possible source of potassium will probably respond to potassium fertilization. In the intense weathering environment characteristic of the "ferrolysis" process, large amounts of halloysite appear to form in situ.

Soils in which the clay fraction has a high 001/002 mica intensity ratio should have the inherent capacity to supply adequate amounts of potassium for normal plant growth. The presence of high charge vermiculite phases with the capacity to fix appreciable amounts of potassium could prevent the equilibrium potassium level in the soil solution from reaching the range required for normal plant growth. Laboratory and greenhouse experiments with soils having wide differences in the 001/002 mica intensity ratio need to be conducted to better establish the dynamics of this relationship. The nature of the "high charge" vermiculite is elaborated in the following paragraph.

Some mica minerals have been weathered to a vermiculite phase which gives a d-spacing of 12.6 A. instead of the normal 14.2 A. spacing; I have designated the 12.6 A. phase as "high charge" vermiculite. It is thought that the charge of this phase is equivalent to about 150 meq/100 g. This "high charge" vermiculite has the potential to fix large amounts of potassium. This material is found in considerable amounts in the samples from the BAU Mymensingh potash experiments.

I suggest that the potential potassium fixing capacity of this group of soils be determined by using the ammonium ion, which has the same charge and size (1.40 A.) and shows similar behavior to that of potassium. The soil or clay would be exposed to concentrations of ammonium, which, on a

soil volume basis, would be equivalent to that of potassium fertilizer applied in a band or strip; this will probably be greater than 5 molar. After establishment of equilibrium, the excess ammonium salt would be removed and the amount of ammonium fixed would be determined by an appropriate method. This should give a good estimate of the amount of potassium that would be fixed under similar conditions.

Some of the X-ray diffractograms suggest the presence of large amounts of amorphous or poorly crystalline materials. These would be expected to have the capacity to fix large amounts of phosphate.

For soil mineral compositions which have the inherent capacity to fix significant amounts of potassium or phosphorus, it is recommended that techniques of fertilizer placement which minimize possible fixation problems, i.e. bands, strips, etc., be used. The heterogenity of the soil-fertilizer system must be recognized in developing an understanding of the chemical reactions that occur when large amounts of fertilizer compounds are concentrated in small soil volumes. As mentioned previously, the concentrations may easily surpass 5 molar and unexpected reactions may occur in these micro soil volumes.

Additional soils samples should be taken on a profile basis to fill any gaps in coverage of parent material - drainage combinations that may occur in the present data. This will help to further confirm the validity of the soil mapping units and establish the uniformity and variability within them. Such information may also provide a sound basis for establishment of broader soil categories from a soil management standpoint.

RECOMMENDATIONS FOR THE FUTURE:

With respect to developments in soil mineralogy research in Bangladesh in the immediate future, I would recommend that the highest priority be given to obtaining additional mineralogical data to complete the parent material - drainage - mineralogy base for the major soil areas. This can be accomplished most quickly and economically by preparing the clay fractions on glass slides and contracting or arranging for the X-ray diffractograms to be made by a laboratory within the country or sent to the USA to a laboratory which has the capabilities of making the analyses. The possibility of arranging for the analyses to be made in the Bangladesh Geological Survey X-ray diffraction laboratory needs to be explored thoroughly.

With respect to long range developments in soil mineralogy in Bangladesh, I would recommend that a central facility for X-ray diffraction analysis be established under the direction of BARC/IADS. For this laboratory to be a viable unit, a committment to a "critical mass" concept must be made by supporting agencies. This "critical mass" concept involves the following components: a scientific administrative unit which is absolutely objective and without local bias, and which has the authorization and power to arrange for immediate shipment of needed parts or repairs. This may involve special exemption from custom regulations and other administrative barriers. Otherwise, scientific development in Bangladesh will continue to be essentially stagnated. Other components of this concept include a sturdy, reliable, and moderately sophisticated X-ray diffraction unit; an air-conditioned laboratory with specifications of a "clean room"; a moderate but adequate supply of spare parts, i.e.

X-ray tubes, electronic tubes, etc.; a couple of highly qualified electronic and instrument specialists; and a system for objectively establishing priorities, charges, etc. for use of the facilities by scientific organizations.

APPENDIX I

BANGLADESH SOIL MINERALOGY ANALYSIS STUDY FOR IADS/BARC

By

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Legend

X = 0-15 cm

Y = 15-30 cm

K = Kaolinite

H = Halloysite

M = Mica

V = Vermiculite

C = Chlorite

S = Smectite (Montmorillonite)

Clay mineral composition values are given in parts per ten. These values are only an approximation and are only intended to be qualitative in nature.

Note: K in Appendix I refers only to Kaolinite and not to the element potassium.

I	Tertiary Hill Rocks	K/HVMcs
II	Modhupur Clay	HS_1VM
III	North. and East. Piedmont	VKMcs
IV	Tista Alluvium	KMVc
V	Ganges River Alluvium	
	Dark Grey	MVSKc
	Brown	VMSKc
VI	Ganges Tidal Alluvium	MSKVc
VII	Chittagong C.P. Alluvium	KMVC
VIII	Old Meghna Est. Alluvium	VKM

I. TERTIARY HILL ROCKS

A. Brown Hill Soils

Soils			Clay Composition						M 001/002	Remarks
			K	H	M	V	C	S		
16.	Samsher Nagar	(8X)		4	2	3	1		*2.3	NF vpd
		(8Y)		4	1	5			*2.8	
17.	Mirsharia	(24X)	3		3	4			4.8	NF wd
		(24Y)	3		3	3	1		4.8	
	Modhupur floodplain	(7X)	6		2	2			*2.4	SF W/D
		(7Y)	6		2	2			*2.4	
3.	Modhupur tila	(6X)	1	4	1	3	1		*2.3	NF pid
		(6Y)	2	5	1	2		Tr	*1.5	

*Ferrolyzed

NF = not flooded
SF = seasonally flooded
W/D = alternately wet and dry

vpd = very poorly drained
pid = poor internal drainage
wd = well drained

II. MODHUPUR CLAY

A. Grey Terrace Soils

	Soils		Clay Composition K	H	M	V	C	S	M 001/002	Remarks
18.	Chhiata	(18X)		4	1			5i**	--	
19.	Lauta	(27X)		5	2	3			4.2	
		(27Y)	2	2	2	4			*2.7	
20.	Amnura	(28X)		2.5	3	3.5		1i**	5.3	
		(28Y)		0.5	6			3.5	5.6	
21.	Nachole	(29X)		2	3			5i**	5.8	
		(29Y)	1		5			4	4.3	

i** = interstratified
* = Ferralyzed

13'

III. NORTHERN AND EASTERN PIEDMONT ALLUVIUM

A. Grey Floodplain Soils

	Soils		Clay Composition						M 001/002	Remarks
			K	H	M	V	C	S		
1.	Devidwar	(1X)	4		2	4	Tr	Tr	1.8*	
		(1Y)	3		2	5			2.0*	
2.	Tipers	(2X)	3		1	6			1.6*	
		(2Y)	1	0.5	0.5	8		Tr	1.5*	

*strongly weathered

IV. TISTA ALLUVIUM

A. Grey Floodplain Soils

	Soils		Clay Composition						M 001/002	Remarks
			K	H	M	V	C	S		
4.	Palashbari	(3X)	4		4	1.5	0.5		3.9	
		(3Y)	4		4	1.5	0.5		4.1	
5.	Gangachara	(4X)	4		4	2			3.3	
		(4Y)	4		4	2			4.5	
6.	Kaunia	(21X)	3		3	3	1		4.0	
		(21Y)	3		3	3	1		3.8	

15

V. GANGES RIVER ALLUVIUM

A. Calcareous Dark Grey Floodplain Soils

B. Calcareous Brown Floodplain Soils

Soils			Clay Composition						M 001/002	Remarks
	A.		K	H	M	V	C	S		
10.	Bagherpara[1]	(22X)	2		3	2	1	2	6.0	
		(22Y)	1		3	6			6.0	
11.	Bagherpara[2]	(23X)	1		3	3		3	6.8	
		(23Y)	1		3	4		2	6.0	
12.	Ishurdi	(30X)	2		3	3		2	5.7	
		(30Y)	2		2	3		3	6.0	
	B.									
13.	Gopalpur	(31X)	2		2	4	1	1	6.0	
		(31Y)	2		3	3	1		6.2	
14.	Sara	(32X)	1		4	5		T	5.7	
		(32Y)	1		4	5			5.5	
15.	Ghior	(33X)	1		2	3		4	6.5	
		(33Y)	1		2	3		4	4.4	

16

VI. GANGES TIDAL ALLUVIUM

A. Grey Floodplain Soils (saline phase)

	Soils		Clay Composition						R‡	M 001/002	Remarks
			K	H	M	V	C	S			
7.	Dumuria	(5X)	2		4	1		3		4.8	
		(5Y)	2		4	1	1	2		3.5	
8.	Bagherhat	(10X)	2		4	1		2		3.2	
		(10Y)	2						8		
9.	Banarpata	(11X)	2		3	3	0.5	1.5		3.1	
		(11Y)	2		3	3	0.5	1.5		2.9	

R‡ = Rectorite

VII. CHITTAGONG COASTAL PLAIN ALLUVIUM

A. Grey Piedmont Soils

Soils		Clay Composition K	H	M	V	C	S	M 001/002	Remarks
22. Pahartali	(25X)	3		3	3	1		3.6	
	(25Y)	3		3	3	1		3.3	

VIII. OLD MEGHNA ESTUARINE ALLUVIUM

A. Non-calcareous Dark Grey Floodplain Soils

Soils		Clay Composition K	H	M	V	C	S	001/002	Remarks
23. Burichong	(26X)	3		2	5			4.5	
	(26Y)	5		1	4			3.3	

SRDI SAMPLES II-Series

II. MODHUPUR CLAY

A. Shallow Weathering (Shallow Red-Brown and Grey Terrace Soils).
B. Deep Weathering (Deep Red-Brown Terrace Soils).

Soils	SRDI No.	Depth(cm)	Clay Composition K	H	M	V	C	S	M 001/002	Remarks
A. Shallow										
(12) Bhatpara	(II-4)	0-13		5	5				5.4	id
Bhatpara	(II-5)	60-90		5	5				5.3	
(13) Gerua	(II-6)	65-90+		6	4				4.0	mw
(14) Gerua	(II-25)	0-10		6	4				*3.3	mw
Gerua	(II-26)	10-20		6	4				5.2	
Gerua	(II-27)	55-75		6	4				5.8	
Gerua	(II-28)	150+		5	5				5.3	
(15) Chhiata	(II-44)	0-9		6	3	1			*2.5	id
Chhiata	(II-45)	20-40		5	4	1			*2.9	
Chhiata	(II-46)	80-100		4	6				4.8	
Chhiata	(II-47)	160-180		2	5	2			5.9	
B. Deep										
(16) Tejgaon	(II-29)	0-10		7	3				*2.7	wd
Tejgaon	(II-30)	12-30		6	4				*2.9	
Tejgaon	(II-31)	90-120		6	4				4.0	
(17) Tejgaon	(II-48)	300-400		6	4				5.8	wd
Subst.	(II-49)	400+		6	4				6.0	
(18) Kalma	(II-13)	0-5		7	3				*2.6	pd
Kalma	(II-14)	13-32		7	3				*2.2	
Kalma	(II-15)	78-90		7	3				*3.0	

*Ferrolyzed

SRDI SAMPLES II-Series

V. GANGES RIVER ALLUVIUM

A. Young Alluvium
B. Old Alluvium

	Soils	SRDI No.	Depth(cm)	Clay Composition K	H	M	V	C	S	M 001/002	Remarks
A.	Young										
(9)	Sara	(II-37)	0-7	2		4	3	1	Tr	5.7	id
	Sara	(II-38)	100+	2		4	1	Tr	3	4.4	
(10)	Ishurdi	(II-39)	0-12	2		3	1	1	3	5.5	
	Ishurdi	(II-40)	20-30	2		3	2	Tr	3	*2.9	
B.	Old										
(11)	Garuri	(II-41)	0-12	2		4	3	1	1	6.0	pd
	Garuri	(II-42)	12-25	2		4	3	Tr	1	5.7	
	Garuri	(II-43)	90+	2		4	3	Tr	1	5.4	

*Ferrolyzed

SRDI SAMPLES II-Series

III. NORTHERN AND EASTERN PIEDMONT ALLUVIUM

A. Jamuna Alluvium (Young Brahm.)

1. Grey Floodplain Soil

	Soils	SRDI No.	Depth(cm)	Clay Composition K	H	M	V	C	S	M 001/002	Remarks
(1)	Dhamrai	(II-16)	0-8	3		4	3	Tr		4.7	pd
	Dhamrai	(II-17)	14-30	3		4	3	Tr		4.8	
	Dhamrai	(II-18)	70-88+	3		4	3	Tr		4.5	
(2)	Sonatala	(II-22)	0-10	3		4	3	Tr	Tr	4.8	pd
	Sonatala	(II-23)	12-32	2		3	3		2	5.1	
	Sonatala	(II-24)	80-90+	3		4	3	Tr	Tr	5.3	
(3)	Singair	(II-32)	0-10	3		3	3		1	5.1	pd
	Singair	(II-33)	25-40	3		4	3	Tr	Tr	5.4	
	Singair	(II-34)	60+	2		4	3		1	5.9	
(4)	Dhamrai	(II-35)	0-10	3		4	3			5.1	
	Dhamrai	(II-36)	10-30	3		4	3			5.0	

B. Old Bral naputra Alluvium

1. Non-calcareous Brown Floodplain Soil
2. Grey Floodplain Soil
3. Non-calcareous Dark Grey Floodplain Soil

1. Non-calcareous

(5)	Sherpur	(II-1)	0-8	3		3	3	1		5.2	md
	Sherpur	(II-2)	8-42	3		4	3	Tr		4.2	
	Sherpur	(II-3)	73-96	3		4	3	Tr		5.7	

2. Grey

(6)	Sonatala	(II-7)	0-10	3		4	3	Tr		5.4	id
	Sonatala	(II-8)	10-33	3		4	3	Tr		6.0	
	Sonatala	(II-9)	55-91	3		5	2	Tr		5.2	
(7)	Silmandi	(II-19)	0-10	3		4	3	Tr		4.6	pd
	Silmandi	(II-20)	15-35	2		5	3	Tr		5.8	
	Silmandi	(II-21)	68-87	3		4	3	Tr		5.1	

SRDI SAMPLES II-Series

B. Old Brahmaputra Alluvium (Cont'd)

	Soils	SRDI No.	Depth(cm)	Clay Composition K	H	M	V	C	S	M 001/002	Remarks
3.	Dark Grey										
(8)	Naraibag	(II-10)	0-6	2	4	2			2	4.3	
	Naraibag	(II-11)	9-32	2	3	3			2	5.6	
	Naraibag	(II-120	71-94	3	2	3			2	4.2	

APPENDIX II

A SUMMARY OF CHEMICAL AND CLAY MINERAL COMPOSITION AND RESPONSES TO POTASSIUM APPLICATION FOR THIRTY TWO LOCATIONS SAMPLED BY BARI

Table 1. Soil Chemical and Mineral Composition and Responses to Potassium Application for Thirty Two Locations Sampled by BARI (incomplete).

Sample No.	Identification (Series)	Village	Thana/ Upazilla	District	pH	K fixation Value	Exch K	Non Exch K	K Ratio	C.E.C	Clay Minerals K*	H	M	V	C	S	Mica 001/ 002	K Treatment	% Yield
1X	Devidwar	Kishon-pur	Baruna	Comilla	5.3	.24	.11	1.4	12	4.8	4	-	2	4	Tr	Tr	1.8	-	88
1Y	"	"	"	"							3	-	2	5	-	-	2.0		
2X	Tippera	Kishon-pur	Baruna	Comilla	4.8	.30	.06	.09	11.5	2.6	3	-	1	6	-	-	1.6	-	85
2Y	"	"	"	"							1	0.5	0.5	8	-	Tr	1.5		
3X	Palashbari	Janoki-nathpur	Mitha-pukur	Rangpur	5.6	.54	.08			5.2	4	-	4	1.5	0.5	-	3.9	-	102
3Y	"	"	"	"							4	-	4	1.5	0.5	-	4.1		
4X	Gangachara	Janoki-nathpur	Mitha-pukur	Rangpur	5.6	.25	.14	1.8	12.9	3.5	4	-	4	2	-	-	3.3	-	121
4Y	"	"	"	"							4	-	4	2	-	-	4.5		
5X	Dumuria	-	Baita-ghata	Khulna							2	-	4	1	-	3	4.8		
5Y	"	-	"	"							2	-	4	1	1	2	3.5		
6X	Modhupur (Tila)	-	-	Sylhet							1	4	1	3	-	1	2.3		
6Y	"	-	-	"							2	5	1	2	-	Tr	1.5		
7X	Modhupur (Floodplain)	-	-	Sylhet							6	-	2	2	-	-	3.0		
7Y	"	-	-	"							6	-	2	2	-	-	2.4		
8X	Shamsher-nagar	-	-	Sylhet							-	4	2	3	1	-	2.3		
8Y	"	-	-	"							-	4	1	5	-	-	2.8		
9X	Modhupur (Tea Estate)	-	-	Sylhet	4.0	.33	.03			3.2	3	-	4	3	-	-	-		
9Y	"			"							6	1	Tr	3	-	-	-		
10X	Bagherat	-	Bati-khandi	Khulna							2	-	4	1	-	2	3.2		
10Y	"	-	"	"							2	-	-	-	-	-	4.7		

Sample No.	Identification (Series)	Village	Thana/ Upazilla	District	pH	K fixation Value	Exch K	Non Exch K	K Ratio	C.E.C	Clay Minerals K*	H	M	V	C	S	Mica 001/ 002	K Treatment	% Yield
11X	Banarpata	-	Satkhira	Khulna							2	-	3	3	0.5	1.5	3.1		
11Y	"	-	"	"							2	-	3	3	0.5	1.5	2.9		
12X	Kendna (35, S)	Nijhuri-bagh	Ghatail	Tangail							3	-	2	3.5	1.5	-	4.3		
14X	Sonatala (16, S)	Kendua	Tangail	Tangail							3	-	3	3	1	-	4.2		
15X	Ghatail (23, S)	Nijhu-ribagh	Tangail	Tangail							4	-	2	3	1	-	4.0		
16X	Savar(1 & 2, S)	Charpak Shitbet-ta	Tangail	Tangail							4	-	4	2	Tr	-	4.8		
17X	Lokdeo (29, S)	Nijhu-ribagh	Tangail	Tangail							3	1	1	5	-	-	3.3		
18X	Chhiata (S_1)	BRRI Field	Joydeb-pur	Dhaka							-	4	1	-	-	5_i 2>	-		
19X	Chhiata (S_4)	BRRI Field	Joydeb-pur	Dhaka							-	4	3	-	-	6	1.2		
20X	Chhiata (S_2)	BRRI Field	Joydeb-pur	Dhaka							-	4	3	-	-	3	2.1		
21X	Kaunia	Porshur-nampur	Rangpur	Rangpur	5.9	None	.01	1.04	104	5.2	3	-	3	3	1	-	4.0	-	49
21Y	"	"	"	"							3	-	3	3	1	-	3.8		
22X	Jessore(1)	Rostam-pur	Bagher-para	Jessore	7.5	1.0	.15	.46	9.7	22.8	2	-	3	2	1	2	4.8	-	112
22Y	"	"	"	"							1	-	3	6	-	-	6.0		
23X	Jessore(2)	Syed Moham-madpur	Bagher-para	Jessore	7.0	None	.22	.70	7.7	24.7	1	-	3	3	-	3	6.8	+	61
23Y	"	"	"	"							1	-	3	4	-	2	6.0		

Sample No.	Identification (Series)	Village	Thana/ Upazilla	District	pH	K fixation Value	Exch K	Non Exch K	K Ratio	C.E.C	Clay Minerals K*	H	M	V	C	S	Mica 001/ 002	K Treatment	% Yield
24X	Minsharai	Fateh-pur	Hathazari	Chitta-gong							3	-	3	4	-	-	4.8	-	79
24Y	"	"	"	"							3	-	3	3	1	-	4.8		
25X	Pahartali	Fateh-pur	Hathazari	Chitta-gong	5.2	.37	.05	1.05	21	5.3	3	-	3	3	1	-	3.6	-	92
25Y	"	"	"	"							3	-	3	3	1	-	3.3		
26X	Burichong	South Kala-gaon	Chandina	Comilla	5.2	.15	.22	2.37	10.5	9.8	3	-	2	5	-	-	4.5	-	62
26Y	"	"	"	"							5	-	1	4	-	-	3.3		
27X	Lauta	Nar-hatta	Kahalu	Bogra	4.6	None	.26	1.5	5.8	12.9	1	5	2	3	-	-	4.2	-	76
27Y	"	"	"	"							2	2	2	4	-	-	2.7		
28X	Amnura	Saroil	Godagari	Rajshahi	5.5	None	.31	3.5	11.3	11.4	-	2.5	3	3.5	-	1i	5.3	+	118
28Y	"	"	"	"							-	0.5	6	-	-	3.5	5.6		
29X	Nachole	Saroil	Godagari	Rajshahi	6.3	None	.27	1.5	5.6	18.3	-	2	3	-	-	5i	5.8	-	36
29Y	"	"	"	"							1	-	5	-	-	4	4.3		
30X	Ishurdi	Kali-kapur	Ishurdi	Pabna	7.9	.3	.17			16.5	2	-	3	3	-	2	5.7	-	120
30Y	"	"	"	"							2	-	2	3	-	3	6.0		
31X	Gopalpur	Kali-kapur	Ishurdi	Pabna	7.7	.26	.22	1.8	8.2	20.4	2	-	3	3	1	-	6.0	-	86
31Y	"	"	"	"							2	-	3	3	1	-	6.2		
32X	Sara	Kali-kapur	Ishurdi	Pabna	7.9	None	.15	1.5	10	8.2	1	-	4	5	-	-	5.7	-	81
32Y	"	"	"	"							1	-	4	5	-	-	5.5		
33X	Ghior	Kali-kapur	Ishurdi	Pabna	6.8	None	.3	3.45	10.1	26	1	-	2	3	-	4	5.5	-	28
33Y	"	"	"	"							1	-	2	3	-	4	4.4		

1> Note: This one sample from Bagherhat had a Rectorite content of 8. It was the only sample showing this mineral.

2> Note: The mark "I" indicates interstratified.

APPENDIX III

LOCATION, DESCRIPTION AND CHEMICAL ANALYSES OF
SAMPLES FROM 18 SITES AT DIFFERENT
DEPTH COLLECTED BY SRDI

SRDI soil samples for clay mineral analyses

Sl. No.	Location: Village, Upazila, District	Soil series	Parent materials	Drainage	General soil type USDA soil taxonomy	Index No.	Horizon	Depth (cm)	Tex. class	Clay %	Org. C	CEC	Exch. K me/100g	pH (H_2O)
1.	Kalampur, Dhamrai, Dhaka	DHAMRAI	Young Brahmaputra or Jamuna alluvium	Poor	Noncalcareous Grey Floodplain Soil, Fluvaquentic Haplaquept	SRDI-16	AP1g	0-8	SiL	25	0.42	15.2	0.14	*
						" 17	B21g	14-30	SiCL	29	0.65	18.7	0.10	7.1
						" 18	IIIC2g	70-88+	SiCL	33	ND	ND	ND	7.8
2.	Hemayetpur, Savar, Dhaka	SONATALA	Ditto	Poor	Noncalcareous Grey Floodplain Soil; Aeric Haplaquept	" 22	APg	0-10	*	*	*	*	*	*
						" 23	B2g	12-32	*	*	*	*	*	*
						24	Cg	80-90+	*	*	*	*	*	*
3.	Daotia, Dhamrai, Dhaka	SINGAIR	Ditto	Poor	Noncalcareous Grey Floodplain Soil; Typic Haplaquept	" 32	AP1g	0-10	*	*	*	*	*	*
						" 33	B2g	25-40	*	*	*	*	*	*
						" 34	Cg	60+	*	*	*	*	*	*
4.	Ditto	DHAMRAI	Ditto	Poor	Ditto	" 35	APg	0-10	*	*	*	*	*	*
						" 36	B2g	10-30	*	*	*	*	*	*
5.	South Silmandi, Narsingdi, Narsingdi	SHERPUR	Old Brahmaputra alluvium	Moderately well	Noncalcareous Brown Floodplain Soil; Aquic Dystric Eutrochrept	" 01	AP	0-8	SiL	13	0.71	10.9	0.12	5.8
						" 02	B2	8-42	SiL	15	0.43	12.5	0.07	6.0
						" 03	C	73-96	SiL	13	ND	ND	ND	6.35
6.	Shekherchar, Narsingdi, Narsingdi	SONATALA	Ditto	Imperfect	Noncalcareous Grey Floodplain Soil; Aeric Haplaquept	" 07	APg	0-10	SiL	13	0.99	9.7	0.12	6.35
						" 08	B2g	10-33	SiL	16	0.51	14.9	0.07	6.41
						" 09	Cg	55-91	SiL	8	ND	ND	ND	6.35
7.	Tulsipur, Narsingdi, Narsingdi	SILMANDI	Ditto	Poor	Ditto	" 19	AP1g	0-10	SiCL	31	0.71	12.4	0.10	5.8
						" 20	B2g	15-35	SiCL	38	0.28	18.0	0.09	6.5
						" 21	IICg	68-87	L	9	ND	ND	ND	6.9
8.	Nayati, Siddhirganj, Dhaka	NARAIBAG	Old Brahmaputra alluvium	Poor	Noncalcareous Dark Grey Floodplain Soil; Aeric Haplaquept	" 10	AP1g	0-6	CL	28	0.99	19.7	0.08	6.6
						" 11	B2g	9-32	SiCL	35	0.43	22.3	0.10	ND
						" 12	IIC	71-94	SiL	17	ND	ND	ND	6.8

Sl. No.	Location: Village, Upazila, District	Soil series	Parent materials	Drainage	General soil type USDA soil taxonomy	Index No.	Horizon	Depth (cm)	Tex. class	Clay %	Org. C	CEC	Exch. K me/ 100g	pH (H_2O)
9.	Mahadebpur, Sibalaya, Manikganj	SARA	Old Ganges alluvium	Imperfect	Calcareous Brown Floodplair Soil; Aquic Eutrochrept.	SRDI-37	AP	0-7	*	*	*	*	*	*
						" 38	C	100+	*	*	*	*	*	*
10.	Ditto	RATHURIA**	Ditto	Poor	Calcareous Dark Grey Floodplain Soil; Aeric Haplaquept	" 39	AP1g	0-12	SiCL	*	*	*	*	*
						" 40	B2g	20-30	SiC	*	*	*	*	*
11.	Bashtia, Ghior, Manikganj	GHIOR**	Ditto	Poor	Ditto	" 41	APg	0-12	*	*	*	*	*	*
						" 42	B2g	12-25	*	*	*	*	*	*
						" 43	C	90+	*	*	*	*	*	*
12.	Panishail, Joydebpur, Gazipur	BHATPARA	Madhupur clay, shallowly weathered	Imperfect	Shallow Red-Brown Terrace Soil; Udic Ustochrept	" 04	AP	0-13	SiC	40	1.23	20.8	0.39	5.0
						" 05	C	60-90	SiC	53	ND	ND	ND	7.7
13.	Tattibari, Savar, Dhaka	GERUA	Ditto	Moderately well	Shallow Red-Brown Terrace Soil; Ultic Ustochrept	" 06	C2	65-90+	SiC	50	ND	ND	ND	4.6
14.	Zahangir Nagar University Campus, Savar, Dhaka	GERUA	Ditto	Ditto	Ditto	" 25	AP	0-10	*	*	*	*	*	*
						" 26	B21	10-20	*	*	*	*	*	*
						" 27	B22	55-75	*	*	*	*	*	*
						" 28	C	150+	*	*	*	*	*	*
15.	Sonda, Tongi, Gazipur	CHHIATA	Madhupur clay, shallowly weathered	Imperfect	Shallow Grey Terrace Soil; Aeric Albaquept	" 44	AP1g	0-9	*	*	*	*	*	*
						" 45	E	20-40	*	*	*	*	*	*
						" 46	C1	80-100	*	*	*	*	*	*
						" 47	C2	160-180	*	*	*	*	*	*
16.	Sundrip, Savar, Dhaka	TEJGAON	Madhupur clay, deeply weathered	Well	Deep Re-Brown Terrace Soil; Typic Paleustult	" 29	AP	0-10	*	*	*	*	*	*
						" 30	B1	12-30	*	*	*	*	*	*
						" 31	B2	90-120	*	*	*	*	*	*

Sl. No.	Location: Village, Upazila, District	Soil series	Parent materials	Drainage	General soil type USDA soil taxonomy	Index No.	Horizon	Depth (cm)	Tex. class	Clay %	Org. C	CEC	Exch. K me/ 100g	pH (H_2O)
17.	Safipur, Kaliakair, Dhaka	TEJGAON	Madhupur clay, deeply weathered	Well	Deep Red-Brown Terrace Soils; Typic Pale stult, substratum	SRDI-48	R1	300-400	*	*	*	*	*	*
						" 49	R2	400+	*	*	*	*	*	*
18.	Madanpur, Savar, Dhaka	KALMA	Ditto, also ferrolyzed	Poor	Deep Grey Terrace Soil;	" 13	APlg	0-5	SiCL	28	2.07	14.8	0.15	5.0
					Aeric Albaquept/	" 14	E2g	13-32	SiL	20	0.71	17.1	0.07	4.9
					Albaquult(?)	" 15	Eg	78-90	SiCL	34	ND	ND	ND	4.9

Note: 1) *Indicates analytical data not yet available.

2) ND - Not determined. CEC, Exch. K, Org. C were not determined for C horizon samples. pH could not be determined for nonavailability of sample.

**Rathuria series, developed in old Ganges alluvium (calcareous), was shown as Ishurdi series in the handout. Similarly Ghior series also was shown as Garuri, however. Part of Ganges sediments were mentioned as young (parent material of Sara and Ishurdi (now Rathuria) series) in the handout, now confirmed as older sediments.

4) Analytical methods: mechanical composition by Hydrometer method, org. C by Walkley Black rapid method, CEC by Boscomb method, Exch. K+ by Flame Photometer and pH from water saturated parts using glass electrode pH meter.

APPENDIX IV

A SUMMARY OF ACTIVITIES AND PERSONS VISITED DURING CONSULTANCY

REPORT OF ACTIVITIES

Date	Location	Contacts	Activity
4/16/85	Dhaka	Dr. Sam Portch	Arrival on BA Flight 145 7:00 P.M.
4/17/85	Dhaka CIDA/AST SRDI BARC Joydebpur BARI	Dr. Sam Portch Dr. Ken Nielsen Mr. S.M. Saheed Dr. Omar Ali Dr. M.S. Islam	Orientation and initial discussions with scientists from cooperating organizations. Toured greenhouse facilities at BARI and was briefed on crop response research program.
4/18/85	Joydebpur BARI Dhaka IADS BARC	Dr. M.S. Islam Dr. Dave Daugherty Dr. R. Feuer	Discussed chemical and crop response data for specific samples with Dr. M.S. Islam. Discussed final bill for X-ray diffraction analyses with Dr. Dave Daugherty (IADS). Briefed Dr. R. Feuer (evaluation team member) on results of mineralogical study.
4/19/85	Dhaka		Holiday
4/20/85	Joydebpur BARI	Dr. Z. Karim	Discussed parent materials of Bangladesh soils and the manner in which drainage conditions influences weathering processes.
4/21/85	Dhaka BARC SRDI	Dr. Z. Karim Mr. S.M. Saheed Dr. A. Habibullah	Met with Dr. Z. Karim and Mr. S.M. Saheed in SRDI to discuss background and location of SRDI soil samples. Discussed X-ray diffraction techniques with Dr. Habibullah.
4/22/85	Dhaka		Calculated mica weathering index (001/002 intensity ratio) and prepared seminar materials.
4/23/85	Dhaka SRDI	Mr. S.M. Saheed Dr. Sam Portch	Discussed weathering trends indicated by clay composition for alluvial deposits of various ages. Developed plans for workshop on soil mineralogy.

Date	Location	Contacts	Activity
4/24/85	Joydebpur BARI	Dr. Z. Karim Dr. Sam Portch	Prepared outline of publication on clay mineralogy of Bangladesh soils. Discussed "ferrolysis" weathering process. Worked on report and seminar.
4/25/85	Dhaka IADS BARC SRDI	Dr. R. Feuer Dr. Z. Karim Mr. S.M. Saheed	Discussed overview of soil mineralogy data for Bangladesh with Dr. Feuer. Discussed coordination and consolidation of parent material data for soil samples from BARI and from SRDI.
4/26/85	Dhaka Joydebpur BARI	Dr. Z. Karim	Compiled parent material data from Dr. Karim and Mr. Saheed and prepared visual aids for seminar and workshop. Discussed weathering trends for various parent materials of samples from BARI.
4/27/85	Dhaka	Dr. Sam Portch Mr. S.M. Saheed Dr. Z. Karim	Mr. Saheed provided revised parent material and soil description data sheets. Discussed report preparation with Dr. Portch. Dr. Karim brought a new version of write-up on parent materials for workshop on soil mineralogy. Prepared vitae and summary report for debriefing session.
4/28/85	Dhaka BARC	Dr. Sam Portch	Participated in Workshop on Soil Mineralogy at BARC. Presented an overview of soil mineralogy and X-ray diffraction techniques and then discussed the results of the clay mineral analysis of the Bangladesh soils. Provided recommendations for use of soil mineralogy data in soil fertility

Date	Location	Contacts	Activity
			and soil classification. Made suggestions for future developments in soil mineralogy in Bangladesh. Workshop attended by 41 scientists and workers.
4/29/85	Dhaka BARC	Dr. Omar Ali Mr. G.H. Sheikh	Discussed future soil chemistry and fertility experiments that can be based on mineralogical results. Attended luncheon for BARC, SRDI, and Dhaka University staff hosted by Dr. Ali.
4/30/85	Dhaka BARC	Dr. Sam Porten	Debriefing at BARC. Departure at 8:15 P.M.

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