Depletion of Organic Matter in Upland Soils of Bangladesh

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Introduction

The importance of soil organic matter for maintaining soil fertility and achieving sustainable agriculture is recognized all over the world. The organic matter in the soils carries out many important functions to improve soil conditions for plant growth. It acts as a source of plant nutrients which are released slowly through the process of mineralization by soil micro-organisms. Organic matter improves the soil structure and increases the cation exchange capacity of the soils to enable plants to spread their root systems with ease, to increase water holding capacity and to enable plants to take up nutrients easily.

When the topic of organic matter in tropical soils is discussed, most soil scientists express the views that tropical and sub-tropical soils have low organic matter contents because of high temperature and high decomposition rates. Therefore, efforts must be made to maintain the present level of organic matter with the adoption of a technology to improve the level. Organic matter conservation is thus essential in maintaining the productivity potential of tropical and sub-tropical soils.

The organic matter status of the soils in Bangladesh is indicated to be very low, ranging between 1.32 to 4.3% (HUQ, 1980). However, the peat soils in Bangladesh contained 19.32% organic matter. The sandy and loamy soils in the hills, terraces, piedmont and ridges of the Tista floodplains had low organic matter (1.9 to 2,8%).

It is now recognized by many agronomist and extension personnel that the organic matter status of most soils is being depleted day by day due to intensive cultivation. But we do not have a clear picture of organic matter depletion. The reasons and causes of the depletion of organic matter in soils may be the greater use of high analysis NPK fertilizers (enhancing mineralization) and the application of irrigation to boost up agricultural production. In addition, due to the shortage of fuel in rural areas, most cultivators leave very few crop residues in their fields for recycling.

SANCHEZ (1976) showed that the decomposition rate of organic matter increases with higher temperature, greater moisture level, aeration, cultivation, etc.

GREENLAND & NYE (1959) showed that bare soil had an organic matter decomposition rate of 13%, while crop rotation with legumes in Trinidad resulted in normal K values.

The maintenance of an optimum level of organic matter in most upland soils of the country is now considered to be necessary for increased and sustainable agricultural production. The purpose of this paper is to review the extent of depletion of soil organic matter during the last 20 years of cultivation and to suggest future options for the maintenance of organic matter.

Degradation of Some Important Physico-Chemical Properties of Soils

It was observed that certain important physico-chemical properties (organic matter %, pH, CEC, etc.) of different soils have been significantly changed due to intensive cultivation during the last 20 years. The status of some physico-chemical properties of important soil series of different zones has been compiled and the data are presented in Table 1. The percentage organic matter in different soils of Madhupur Tract ranged from 1.30 to 2.40 during 1969-1970, decreasing to 0.6-1.70 during 1989-1990. The percentage clay in top soils also decreased in all soil series, probably due to downward movements or clay destruction (partly ferrolysis) under the influence of redox potential and/or intensive weathering/cultivation. High rainfall and irrigation caused the removal of some soluble and exchangeable cations from all soils. This process of cation removal was found to be especially great in coarse-textured soils. The cation exchange capacity (CEC) of most soils has also decreased due to the gradual depletion of organic matter and the loss of clays from top soils. The acidity level of most soils has increased due to intensive cultivation. The percentage clay and amount of CEC have decreased considerably with increasing acidity in this tract during the last 20 years of intensive cultivation.

A similar trend in the changes in organic matter content, percentage clay, CEC, pH and active acidity was also observed in most other highland soils due to intensive cultivation with the use of NPK fertilizers and irrigation practices in other agro-ecological regions: Barind Tract, Old Himalayan Piedmont Plain, Tista Meander Floodplain, Northern & Eastern Hills, Old Meghna Estuarine Floodplain, High Ganges River Floodplain and Old Brahmaputra Floodplain soils. The degradation of the physico-chemical properties of the soil was found to be quite severe in hill soils, terrace soil and sloppy highlands.

Table 1

Status of some physico-chemical properties of important soil series in different agro-ecological zones (AEZ) in Bangladesh

Name of AEZ	Location/ Soil Series	Land type	Organic matter, %		Clay content, %		pH		Active acidity		Cation exchange	
			Pr.	P.	Pr.	P.	Pr.	P.	Pr.	P.	Pr.	P.
I. Madhupur Tract	1. Kashimpur	Highland	0.98	1.30	14.0	15.0	5.3	5.6	0.2	0.0	7.7	8.1
	2. Tejgaon	Highland	1.53	2.12	17.0	20.0	5.1	6.1	0.5	0.1	12.0	12.5
	3. Chhiata	Highland	0.60	1.28	29.2	34.0	5.0	5.3	0.3	0.2	7.7	8.6
	4. Kalma	Med. highland	1.70	2.40	27.0	29.0	5.1	5.3	0.35	0.1	10.	12.4
II. Barind Tract	1. Noadda	Highland	1.30	1.38	20.0	21.7	5.6	5.7	0.1	0.0	8.0	8.1
	2. Chandra	Med. highland	1.20	1.29	13.0	14.0	5.4	5.6	0.2	0.1	6.0	7.7
	3. Belabo	Highland	1.30	2.00	16.0	20.0	4.8	4.9	0.7	0.5	7.0	9.3
	4. Amnura	Highland	0.90	1.43	15.0	18.0	5.5	4.7	0.2	0.0	7.5	8.5
	5. Lauta	Highland	1.40	1.55	25.0	27.0	4.6	4.8	1.2	0.2	10.0	11.4
	6. Ekdala	Highland	0.80	1.06	23.0	25.0	4.3	4.6	0.8	1.0	11.0	12.0
III.. Old Himalayan Piedmont P.	1. Baliadangi	Highland	1.30	1.32	10.0	11.3	4.9	5.0	0.4	0.2	10.0	11.3
	2. Ranisankail	Highland	1.50	1.65	15.0	17.0	4.8	5.1	0.85	0.2	8.0	10.0
	3. Pirgachha	Highland	1.08	1.60	10.0	11.4	5.7	5.0	0.1	0.4	6.0	8.6
IV. Tista Meander Floodplain	1. Domar	Highland	1.40	1.60	9.0	10.0	4.8	5.3	0.7	0.3	5.0	5.2
	2. Gangachara	Highland	1.50	1.58	17.0	17.8	5.8	6.6	0.1	0.0	11.0	11.7
	3. Kaunia	Highland	0.80	1.46	18.0	29.0	5.4	5.5	0.2	0.1	8.0	9.7
	4. Polashbari	Highland	1.30	1.50	15.0	20.0	5.6	5.7	0.1	0.0	10.5	13.0

Name of AEZ	Location/ Soil Series	Land type	Organic matter, %		Clay content, %		pH		Active acidity		Cation exchange	
			Pr.	P.	Pr.	P.	Pr.	P.	Pr.	P.	Pr.	P.
V. Northern & Eastern Hills	1. Rangamati	Highland	1.00	1.49	16.0	19.1	4.7	4.9	0.7	0.3	8.0	15.5
	2. Sitakund	Highland	1.50	2.46	15.0	16.0	4.8	5.1	0.7	0.2	12.0	14.1
	3. Mirsarai	Highland	1.46	2.16	11.0	12.4	4.9	5.2	0.7	0.2	7.0	8.0
VI. Old Meghana Estuarine Floodpl.	1. Tippera	Highland	1.50	2.61	20.0	21.3	5.0	5.5	0.35	0.2	10.0	12.9
	2. Debidwar	Highland	1.00	1.92	35.0	90.3	4.8	5.0	0.6	0.4	18.0	21.2
	3. Burichang	Highland	1.00	1.96	15.0	16.1	5.5	5.7	0.2	0.0	6.0	6.9
VII. High Ganges River Floodplain	1. Sara	Highland	0.90	1.09	11.0	12.0	7.9	7.8	0.0	0.0	9.0	10.9
	2. Darsana	Highland	0.30	0.64	16.0	18.0	7.5	6.8	0.0	0.0	10.0	11.7
	3. Ishurdi	Highland	1.30	1.50	40.0	55.0	7.9	7.9	0.0	0.0	25.0	26.7
	4. Gopalpur	Highland	1.40	1.61	20.0	33.0	7.7	7.9	0.0	0.0	16.0	17.1
VIII. Old Brahmaputra Floodplain	1. Sonatala	Highland	1.00	1.09	15.0	16.0	5.7	6.8	0.0	0.0	12.0	12.3
	2. Silmandi	Highland	0.90	1.32	22.0	25.0	5.4	5.6	0.2	0.1	8.0	9.3
	3. Lokdeo	Highland	1.50	2.16	24.0	25.0	5.6	5.6	0.0	0.0	11.0	11.6
	4. Dramral	Med. highland	1.50	1.65	10.0	46.6	5.5	5.6	0.2	0.0	16.0	17.5

Remarks: Pr: present (1989-1990); P: 20 years ago

Increase in Cropping Intensity

The average cropping intensity and the dominant cropping pattern in different zones during 1969-1970 and 1989-1990 are summarized in Tables 2-4.

Table 2
Average cropping intensity during 1969-1970

Code of AEZ, Land type	Dominant cropping pattern	Cropping Intensity
I. 1. - Highland	Aus - Groundnut, or Jackfruit	100 - 200
I. 2. - Highland	B. Aus - Groundnut/early Rabi crops	150 - 200
I. 3. - Highland	Aus - Groundnut, or Jackfruit	100 - 200
I. 4. - Highland	B. Aus - Groudnut	150 - 200
II.4. - Medium highland	Aus - T. Aman - Fallow	100 - 200
II.5. - Medium highland	Aus - T. Aman - Fallow	100 - 200
II.6. - Medium highland	T. Aman - Fallow	100
III.1. - Highland	Aus - Rabi crops	100
III.2 - Highland	Aus - Rabi crops	100
III.3. - Highland	Aus - Rabi crops	150
	Sugarcane	100
IV. 1. - Highland	Aus - Rabi crops	150
IV. 2. - Highland	Aus - Rabi crops	150
IV. 3. - Medium highland	Aus/Jute - T. Aman/Rabi crops	200
IV. 4. - Highland	Aus/Mesta - rabi crops	150
V. 1. - Highland	Forest (Tea, Teak, Garjan)	100
V. 2. - Highland	Forest	100
V. 3. - Highland	Aus - T. Aman - Fallow	200
VI. 1. - Highland	Mixed Aus/Jute - Aman/ Rabi crops	200
VI. 2. - Highland	Mixed Aus/Jute - Aman/ Rabi crops	200
VI. 3. - Highland	Aus - T. Aman - Fallow	200
VII. 1. - Highland	Aus/Millet - Rabi crops	150
VII. 2. - Highland	Aus - Rabi crops	150
VII. 3. - Highland	Aus/Jute - Rabi crops	150
	or sugarcane	100
VII. 4. - Med. highland	Mixed Aus + Aman - Rabi crops	150
VIII. 1. - Med. highland	Aus - T. Aman - Fallow	200
VIII. 2. - Med. highland	Aus. - T. Aman - Rabi crops	250
VIII. 3. - Med. highland	Aus/Jute - Rabi crops	150

Remarks: For name of agro-ecological zones (AEZ) and locations, see Table 1. Rabi crops: includes pulses and oilseeds (short duration crop); HYV: high yielding varieties; * grown under irrigated conditions

Cropping season	*Time of sowing/transpl.*	*Time of harvesting*
T. Aus - Transplant Aus.	Mid-April to Mid-June	Mid-July to Mid-August
T. Aman - Transplant Aman	Mid-June to Mid-August	Mid-November to Mid-Jan.
Boro	Mid-December to Mid-Febr.	Mid-April to June
Rabi crops	Sown in winter	Spring to early summer

The average cropping intensity in different zones during 1969-1970 was 100-200%, whereas this cropping intensity rose to 200-300% in 1989-1990 due to the modernization and intensification of agriculture during the last 20 years. The maximum increase in cropping intensity (200-300%) was observed in

Table 3

Extent of average cropping intensity in different agro-ecological zones (AEZ) (1989-1990)

AEZ	Land type	Dominant cropping pattern	Cropping intensity
I.	Highland	B. Aus - Rabi crops - Fallow	150
		Sugarcane + Rabi crops	150
	Medium highland	Aus/Jute - T. Aman	200
		Wheat - T. Aman - Rabi crops	300
		Fallow - T. Aman - HYV Boro*	200
II.	Highland	Fallow - T. Aman - Fallow	100
		Fallow - T. Aman - Rabi crops	150
		Sugarcane	100
		Fallow - T. Aman - HYV Boro*	200
		Fallow - T. Aman - Wheat	200
III.	Highland	Aus - Fallow - Pulses	200
		Sugarcane + Spices	200
		Fallow - T. Aman - HYV Boro*	200
		T. Aman - Fallow - Potato*/Wheat*	200
	Medium highland	Aus/Jute - T. Aman - Fallow	200
		Fallow - HYV Boro - T. Aman	200
		T. Aus - T. Aman - Wheat/Potato*	300
IV.	Highland	Aus - Fallow - Rabi crops	200
	&	Aus/Jute - Wheat - T. Aman	300
	Medium highland	Sugarcane + Potato	200
		Fallow - HYV Boro* - T. Aman	200
		T. Aus* - T. Aman - Potato*	300
V.	Highland	Fallow - T. Aman - Rabi crops	150
	(Agric. land)	T. Aus - T. Aman - Vegetables	250
VI.	Highland	Aus/Jute - T. Aman - Fallow/Rabi cr.	200-300
		Fallow - T. Aman - HYV Boro	200
VII.	Highland	Aus/Jute - Fallow - Pulses/Wheat/ Rabi crops	200
		Sugarcane + Pulses/Wheat	150-200
		T. Aus* - T. Aman - Wheat/Potato*	300
VIII.	Medium highland	Aus/Jute - T. Aman - Fallow	200
		T. Aus* - T. Aman - Wheat/Pulses/ HYV/Boro	300

Remarks: For abbreviations and explanations: See Table 1 and Table 2.

highland and medium highland soils of the Tista Meander Floodplain, the High Ganges River Floodplain and the Old Brahmaputra Floodplain (Table 3).

There was a pronounced depletion in the organic matter, ranging from 9-46% in the highlands of different zones of the country. The maximum depletion of organic matter from topsoils was found in the old Meghna Estuarine Floodplain and in the Northern and Eastern Hills (Table 4). This was probably due to high rainfall and an increase in cropping intensity in these regions.

Table 4

Depletion of soil organic matter status in different agroecological regions (AEZ) of Bangladesh during the last 20 years

AEZ	Average cropping intensity		Organic matter % (average) (OM)		Total depletion of OM, %
	1969-1970	1989-1990	1969-1970	1989-1990	
I.	150-200	150-300	1.78 (1.3-2.4)	1.20 (0.6-1.7)	32.58
II.	100-200	100-200	1.45 (1.06-2.0	1.15 (0.9-1.4)	20.69
III.	100-200	200-300	1.32 (1.0-1.65	1.20 (0.8-1.5)	9.00
IV.	150-200	200-300	1.55 (1.46-1.6)	1.23 (0.8-1.5)	20.60
V.	100-200	200-250	2.04 (1.49-2.46)	1.32 (1.0-1.5)	35.30
VI.	200	200-300	2.16 (1.92-2.61)	1.17 (1.0-1.5)	45.80
VII.	100-150	200-300	1.21 (0.64-1.61)	0.98 (0.3-1.4)	19.00
VIII.	150-250	200-300	1.56 (1.09-2.16)	1.23 (0.9-1.5)	21.15

Intensive rainfall accompanied by a rapid decrease in organic matter is considered to be the reason for structural deterioration (CUNNINGHAM, 1963). Perhaps the best management practice is to prevent compaction, by protecting the soil surface with mulches or plant canopies which decreased both the energy of raindrops and the rate of organic matter decomposition as well.

If we carefully look into the present status of organic matter in different major zones, this low status is undoubtedly an alarming situation if the desired crop yield level and soil health is to be sustained. this trend of depletion of the organic matter will be severe in the case of light textured soils such as sandy soils, loams, etc. It is high time to develop a technology for the management of organic matter in soils with green manuring to improve the level of organic matter for sustainable, high-yielding agriculture.

Possible options for the management of soil organic matter

1. Introduction of a legume-based cropping pattern especially in Barind and Madhupur Tract Soils.
2. Green manuring with Dhaincha (Sesbania) before T. Aman in a rice-based cropping pattern.
3. Farmers must be motivated not to use cowdung as fuel. They should be advised to grow quick-growing fuel trees on the wasteland in and around their homesteads.
4. Farmers should be advised not to remove crop residues. These should be ploughed under during the preparation of the land.
5. Agricultural extension workers should motivate and educate the farmers to collect and conserve all available sources of organic wastes, to prepare organic manures/compost from them and to apply these to their fields.
6. Use of bio-fertilizers in the cultivation of grain legumes and cultivation-/use of Azolla and Blue-green algae in wetland rice cultivation.
7. Mulching conserves organic matter by decreasing soil temperatures. The use of mulches should be promoted wherever possible.
8. Pilot projects should be initiated in soils highly depleted of organic matter to see what practice or combination of practices are appropriate for the improvement of the organic matter level and its sustainance.

Summary

The management and conservation of soil organic matter are essential for maintaining or increasing the productivity of most agricultural soils. Data on the organic matter status, along with associated properties such as CEC, pH, active acidity and percentage clay determined for different soils in Bangladesh during 1969-1970 and 1989-1990 have been compiled and reviewed. The cropping intensity, based on the dominant crops grown during the above periods has been found to be 100-200% and 200-300%, respectively, indicating greater exploitation of the soils. It was observed that soil organic matter was significantly depleted due to intensive cultivation and the modernization of agriculture. The acidity level of most upland soils has also increased with parallel decrease in the CEC value and percentage clay and a decline in soil fertility.

The depletion of organic matter ranged from 9-45% during the last 20 years of cultivation. Some management options are suggested to maintain or improve organic matter at the desired level in all soils for sustainable agriculture and good soil health in different Agro-Ecological Zones (AEZ) of Bangladesh.

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