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Evaluation of Physico-chemical properties of old Alluvium soil of Malda District, West Bengal

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Abstract
An evaluation of Physico-chemical properties of 27 soil samples from 3 different blocks of Malda district (West Bengal) in different depths (0–15, 15–30 and 30–45 cm) was carried out during the year of 2020–2021. The present investigation was objectified as determination of soil Physico-chemical properties to analyse the soil fertility status with finding out the deficiency and toxicity of different soil nutrients. Soil samples were analysed using standard laboratory techniques and statistical analysis. Findings have shown sandy loam to loam soil texture and bulk density range of 1.33–1.81 Mg m^{-3} with good Water Holding Capacity (44.71–59 %). Soil pH is slightly acidic to slightly alkaline with a mean value range of 6.29–8.15 and the Electrical Conductivity suitable for all crops and free from salinity with a mean value of 0.12–0.37 dS m^{-1}. Soil Organic Carbon was medium to high range (0.45 – 0.9 %) than standard, due less decomposition of organic matter of the soil. Available Nitrogen (mean value range of 250.1 – 504 Kg ha^{-1}), Phosphorus (mean value range of 8.73–21.6 Kg ha^{-1}) and Potassium (mean value range of 161.3 – 279.6 Kg ha^{-1}) are adequate whereas, Sulphur (13.23–31.32 Kg ha^{-1}) is deficient. Calcium and Magnesium are sufficient (7.27 – 11.87 and 4.63 – 8.13 meq/100g). In case of micro-nutrients, Iron (5.8–12.15 mg Kg^{-1}) and Copper (0.16 – 0.69 mg Kg^{-1}) content are sufficient whereas, Zinc content (0.16–0.87 mg Kg^{-1}) is slightly deficient.

Keywords: Soil fertility, soil nutrient, Physico-chemical, adequate, sufficient, deficient

Introduction
Soil is a dynamic, 3-dimensional natural body of the landscape developed from the weathering of rocks through various pedogenic processes, consisting of mineral & organic constituents processing a definite set of physical, chemical and biological properties, having a variable depth covering the surface of earth & providing a medium for growth of the terrestrial plant (Verma *et al.,* 2019) [17].

The global drive for sustainable agricultural systems involves optimizing agricultural resources to satisfy human needs and at the same time maintaining the quality of the environment and sustaining natural resources. The concept of soil health and soil quality has consistently evolved with an increase in the understanding of soils and soil quality attributes. The deficiency of nutrients has become major constraint to productivity, stability and sustainability of soils (Chaudhari *et al.,* 2013) [2]. Soil quality encompasses many properties and processes as the structural stability of the aggregates water retention capacity of soils and capability of nutrient cycling. Of the several elements known to be essential for plant growth, macronutrients (N, P, K), Secondary nutrients (S, Ca, Mg) and micronutrients (Fe, Mn, Zn and Cu) are important soil elements that control its quality. Because of imbalanced and inadequate fertilizer are coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined rapidly under intensive agriculture in recent years. (Singh *et al.,* 2017) [14].

The soils of West Bengal are broadly divided into four types and those are Mountain soils, Alluvial soils, Red soils and Saline soils. As per recent studies by the Department of Agriculture soil is categorized into six groups based on analysis of soil profile and those are Mountain and Forest Soil, Old Alluvium, New Alluvium, Red Soil, Laterite Soil, Saline Soil. (Ghosh *et al.,* 2020) [4].

Malda district is under Lower Gangetic Plain Region (III) Agro-climatic zone by Planning Commission. Geographical area of Malda district is 3733 square kilometer with cultivable area of 2959 square kilometer. Soil type is Deep Clay to clay loam low land (Tal), Medium sandy loam to loam medium land (Diara) and Deep clay loam high land (Barind).

Soil of Malda district contains good physical properties and fertile with soil nutrients to grow major crops in the area. The study has been done by analysis of soil physical properties, chemical parameters along with soil nutrients. Determination of deficiency and toxicity has been done by comparing the findings with certain standards of classification. The work was carried out with standard laboratory analysis.

Materials And Methods

West Bengal covers 88,752 sq. km (34,267 sq. miles) and ranks 14th state by area in India. It extends from 22°59'12.4794" N, and 87°51'18"E. Malda district situated at 25°00'39.03" N and 88°08'27.95" E at mean sea level of 25 meters is under Lower Gangetic Plain Region (III) Agro-climatic zone by Planning Commission. Geographical area of Malda district is 3733 sq. km. with cultivable area of 2959 square kilometer. The area for the research study involves 3 blocks of Malda district *i.e.,* Chanchal-II, Harishchandrapur-I and Harishchandrapur-II.

Soil samples were collected during kharif season of 2021from 9 different villages of 3 blocks of Malda district in 3 different depths i.e., 0-15 cm, 15-30 cm and 30-45 cm by the help of augar and khurpi.

Soil samples were analysed using different standard laboratory techniques and statistical analysis of using Completely Randomised Design (CRD). Bulk Density, Particle Density, Porosity and Water Retaining Capacity were measured by the help of Muthuaval *et al.,* (1992) [11], method using graduated measuring cylinder. Colours of soil samples were determined by using Munsell Colour Chart and Textural classes were assessed by using Bouyoucos Hydrometer.

Chemical properties such as Soil pH (1:2) and Electrical Conductivity (1:2) were determined by Digital pH Meter and Digital Conductivity Meter respectively. Soil organic Carbon was evaluated by Wet Oxidation method given by Walkley and Black (1947) [18]. Estimation of Nitrogen was done by Alkaline $KMnO_4$ Method of Subbiah and Asija (1956) [15]. Assessment of Phosphorus was completed by using Photometric Colorimeter (Olsen *et al.,* 1954) [12] and Potassium by Flame Photometer. Sulphur by using Turbid Metrical method (Chesnin and Yien 1951). Calcium and Magnesium was determined by Versanate Titration method (Gupta,1999) [5] while heavy metals were determined using DTPA method (Lindsey and Norvell, 1978) [8].

Result and Discussion

A. Physical Parameters

In dry condition, Soil Colour of the samples were light brownish yellow, grayish brown, light gray, very pale brown, pale brown, light yellowish brown whereas, in wet conditions, dark grayish brown, very dark grayish brown, grayish brown, brown, pale brown, olive brown, dark brown, brown/dark brown and dark yellowish brown. High organic content causes the dark colours in these soil samples. The textural classification shows Sandy loam in eight villages and Loamy soil in one village after using Bouyoucos Hydrometer method. The range of Sand (%) of the collected samples from 43.53 to 67.37 %, while Clay (%) ranges from 8.68 to 15.93 % and Silt (%) ranges from 22.03 to 40.54%. The Bulk Density and Particle Density of the soil samples were in 1.33 – 1.81 and 2.22 – 2.96 Mg m^{-3} respectively, with mean of 1.54 and 2.56 Mg m^{-3} respectively. Porosity and Water Retaining Capacity of the collected soil samples ranges between 29.8 – 49.9 and 44.71 – 59 % respectively, with the mean value of 39.46 and 54.33 % respectively.

Table 1: Soil Textural Classes and Soil Colours of Malda district.

Villages	Soil Textural Classes	Soil Colour	
		Dry Conditions	Wet Conditions
Bhabanipur	Sandy Loam	Light Brownish gray - Grayish Brown	Dark Grayish Brown - Very Dark Grayish Brown
Rampur	Sandy Loam	Light Gray - Pale Brown	Dark Grayish Brown - Grayish Brown
Rasulpur	Sandy Loam	Light Brownish gray - Light Gray	Dark Grayish Brown - Brown
Elam	Sandy Loam	Very Pale Brown	Pale Brown - Olive Brown
Bejpura	Sandy Loam	Light Gray	Dark Grayish Brown - Brown
Gorakhpur	Sandy Loam	Pale Brown - Very Pale Brown	Dark Grayish Brown - Dark Brown
Gobindapara	Sandy Loam	Very Pale Brown	Brown - Dark Brown
Kanua	Loam	Light Gray - Very Pale Brown	Brown / Dark Brown - Olive Brown
Bot Tola	Sandy Loam	Light Yellowish Brown - Very Pale Brown	Dark Yellowish Brown - Dark Brown

Table 2: Physical properties of soil samples from Malda district

Villages	Bulk Density (Mg m^{-3})		Particle Density (Mg m^{-3})		Porosity (%)		Water Retaining Capacity (%)	
	Ranges	Mean	Ranges	Mean	Ranges	Mean	Ranges	Mean
Bhabanipur	1.42 - 1.81	1.63	2.22 - 2.85	2.58	35.65 - 37.65	36.50	55.51- 59	57.11
Rampur	1.53 - 1.66	1.62	2.35 - 2.66	2.50	33.33 - 37.34	35.07	52.75 - 54.65	53.61
Rasulpur	1.42 - 1.53	1.49	2.22 - 2.85	2.47	35.65 - 46.02	40.04	56.72 - 57.82	57.12
Elam	1.33 - 1.53	1.43	2.5 - 2.96	2.77	46.67 - 49.87	48.19	52.75 - 54.65	54.02
Bejpura	1.42 - 1.53	1.46	2.35 - 2.85	2.57	39.21 - 46.02	42.70	44.71 - 54.45	51.05
Gorakhpur	1.33 - 1.42	1.39	2.22 - 2.85	2.58	39.94 - 49.87	45.37	49.47 - 59	53.97
Gobindapara	1.42 - 1.81	1.63	2.35 - 2.85	2.57	33.33 - 39.21	36.25	49.90 - 54.23	52.20
Kanua	1.33 - 1.66	1.55	2.22 - 2.5	2.36	29.08 - 39.94	34.12	46.77 - 59	53.47
Bot Tola	1.42 - 1.81	1.68	2.5 - 2.85	2.67	31.65 - 42.86	36.90	52.18 - 59	56.37

B. Chemical Parameters

Soil pH : Soil pH of the collected samples were slightly Acidic to slightly Alkaline, ranges 6 – 9.3 with the overall mean value of 6.91 (*i.e.* Neutral). Soil macro and micro nutrients availability should be optimum for the growth of major crops. There will be no limitation in major crop production due to soil reaction in this area. Similar results were reported previously by Karmakar *et al.,* (2020) [7].

Electrical Conductivity: The EC of the collected soil

samples were suitable to all crops, ranges 0.11 – 0.47 dS m^{-1} with the overall mean value of 0.19 dS m^{-1}. So, crops grown in these areas do not require any measurement to prevent excess soluble salt content. Similar results were reported previously by Ghosh *et al.,* (2020) [4], Karmakar *et al.,* (2020) [7].

Soil Organic Carbon: Organic Carbon of the collected soil samples was adequate with respect to standards and ranges 0.36 – 0.93 % with the overall mean value of 0.60 %. Less infiltration of organic matter to the soil profile is the reason for high Organic Carbon availability. Medium to High range of Soil Organic Carbon will empower productivity of most of the crops. Similar results were reported previously by Karmakar *et al.,* (2020) [7].

Table 3: Chemical Properties of soil samples from Malda district.

Villages	Soil pH		Electrical Conductivity (dS m^{-1})		Soil Organic Carbon (%)	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
Bhabanipur	7.41 – 7.76	7.61	0.17 – 0.28	0.24	0.86 – 0.93	0.90
Rampur	6.4 – 6.8	6.60	0.15 – 0.17	0.16	0.8 – 0.86	0.84
Rasulpur	6 – 6.76	6.40	0.12 – 0.15	0.14	0.5 – 0.71	0.59
Elam	6.12 – 6.5	6.29	0.11 – 0.15	0.13	0.43 – 0.67	0.56
Bejpura	6.65 – 9.3	8.15	0.13 – 0.2	0.17	0.5 – 0.69	0.57
Gorakhpur	6.4 – 6.95	6.70	0.16 – 0.2	0.18	0.44 – 0.49	0.47
Gobindapara	7.05 – 7.62	7.40	0.14 – 0.19	0.17	0.36 – 0.77	0.52
Kanua	6.3 – 6.6	6.47	0.11 – 0.13	0.12	0.5 – 0.53	0.51
Bot Tola	6.2 – 6.76	6.57	0.29 – 0.47	0.37	0.43 – 0.46	0.45

Available Nitrogen: The available Nitrogen of the collected soil sample were in medium range than Muhr *et al.,* standards and ranges 201.6 – 520.8 Kg ha^{-1} with the overall mean value of 336.0 Kg ha^{-1}. Available Nitrogen is directly correlated with Soil Organic Carbon so, sufficient Nitrogen content suggests adequate organic matter availability. Similar results were reported previously by Panwar *et al.,* (2014), Karmakar *et al.,* (2020) [7]

Available Phosphorus: The available Phosphorus of the collected soil samples ranges between 5.34 – 29.51 Kg ha^{-1} with the overall mean value of 14.2 Kg ha^{-1}, standard deviation of 4.38. Available Phosphorus was medium to higher with respect to standards and sets up for good crop production. Similar results were reported previously by Panwar *et al.,* (2014)

Available Potassium: Available Potassium of the collected soil sample ranges 121 – 286.2 Kg ha^{-1} with the overall mean value of 211.7 Kg ha^{-1}, standard deviation of 20.05. Potassium content was in medium range than standards due to less K loss from organic residues during weathering process. Similar results were reported previously by Karmakar *et al.,* (2020) [7], Ghosh *et al.,* (2020) [4].

Table 4: Status of Primary Nutrients in the soil samples from Malda district.

Villages	Available Nitrogen (Kg ha^{-1})		Available Phosphorus (Kg ha^{-1})		Available Potassium (Kg ha^{-1})	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
Bhabanipur	481.6 - 520.8	504.0	13.17 – 29.51	21.67	273.1 – 286.2	279.6
Rampur	448 - 481.6	468.5	12.53 – 17.92	15.53	215.0 – 268.8	241.9
Rasulpur	280 - 397.6	330.4	8.93 – 18.55	13.34	174.7 – 228.5	201.6
Elam	240.8 - 375.2	311.7	5.34 – 12.94	8.92	147.8 – 188.2	174.7
Bejpura	280 - 386.4	317.3	10.73 – 22.97	17.21	121.0 – 161.3	138.9
Gorakhpur	246.4 - 274.4	265.1	14.32 – 23.31	19.11	161.3 – 228.5	183.7
Gobindapara	201.6 - 431.2	291.2	7.14 – 12.53	9.54	147.8 – 174.7	161.3
Kanua	280 - 296.8	285.6	8.93 – 19.71	13.73	241.9 – 276.3	262.3
Bot Tola	240.8 - 257.6	250.1	7.14 – 10.1	8.73	241.9 – 273.1	261.3

Available Sulphur: Available Sulphur content of the collected soil sample were in lower to medium range than standards and ranges 10.55 – 41.20 Kg ha^{-1} with the overall mean value of 21.04 Kg ha^{-1}, standard deviation of 4.99. Low to moderate sulphur content is due to changes in agricultural practices and growing of high-yielding crops. Similar results were reported previously by Ghosh *et al.* (2020) [4].

Calcium: Calcium content of the collected soil sample ranges 6 – 13.8 meq/100g with the overall mean value of 9.23 meq/100g, standard deviation of 1.03. Calcium content considered higher than standard and is due to good rainfall in the area. Similar results were reported previously by Panwar *et al.,* (2014).

Magnesium: Magnesium content of the collected soil sample ranges 3.9 – 8.6 Meq/100g with the overall mean value of 6.37 Meq/100g, standard deviation of 0.77. Magnesium content considered higher than standard because of sufficient rainfall. Similar results were reported previously by Panwar *et al.,* (2014).

Table 5: Status of Secondary Nutrients in soil samples from Malda district.

Villages	Available Sulphur (Kg ha^{-1})		Calcium (meq 100g $^{-1}$)		Magnesium (meq 100g $^{-1}$)	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
Bhabanipur	10.55 – 15.8	13.23	9.6 – 13.8	11.20	7.6 – 8.6	8.13
Rampur	12.05 – 14.4	13.62	11.2 – 12.4	11.87	5.4 – 8.2	6.80

Rasulpur	14.85 – 30.55	21.25	7.2 – 11.4	9.40	6.3 – 8.1	7.27
Elam	11.15 – 26.05	19.25	7.8 – 9.8	8.60	4.9 – 7.2	5.90
Bejpura	11.65 – 23.05	17.33	6.8 – 11.6	9.27	6.5 – 7.2	6.80
Gorakhpur	20.85 – 40.7	31.32	7.8 – 8.6	8.23	7.2 – 7.6	7.37
Gobindapara	20.80 – 29.35	25.40	8.6 – 11.4	9.60	4.1 – 5.6	4.63
Kanua	18.70 – 41.2	28.70	6 – 8.2	7.27	3.9 – 6.8	5.43
Bot Tola	15.55 – 25.95	19.22	7.2 – 8.2	7.67	3.9 – 6.3	5.03

Heavy Metals: The collected soil samples had Fe, Cu and Zn in ranges of 5.8 – 12.15, 0.16 – 0.69 and 0.16 – 0.87 mg Kg^{-1} respectively and mean value of 8.38, 0.33, 2.47 and 0.52 mg Kg^{-1} respectively. The assessed range of Cu and Fe signifies the sufficiency whereas, Zn was found below the critical level in most of the samples. Neutral pH of the samples is responsible for optimum Cu and Fe content in the soil. Moderate organic matter causes moderate Cu content. Similar results were reported previously by Panwar *et al.*, (2014).

Table 6: Status of Heavy Metals (Fe, Cu and Zn) in soils of Malda district.

Villages	Iron (Fe) (mg Kg^{-1})		Copper (Cu) (mg Kg^{-1})		Zinc (Zn) (mg Kg^{-1})	
	Ranges	Mean	Ranges	Mean	Ranges	Mean
Bhabanipur	5.8 – 8	6.6	0.35 – 0.59	0.45	0.18 – 0.23	0.20
Rampur	8.1 – 10.8	9.52	0.28 – 0.37	0.32	0.39 – 0.87	0.67
Rasulpur	10.4 – 12.2	11.03	0.17 – 0.69	0.38	0.4 – 0.72	0.60
Elam	6.5 – 7.4	6.82	0.17 – 0.31	0.24	0.16 – 0.65	0.33
Bejpura	6.2 – 6.6	6.36	0.16 – 0.57	0.32	0.38 – 0.72	0.49
Gorakhpur	8.1 – 9.9	9.17	0.21 – 0.25	0.23	0.56 – 0.77	0.66
Gobindapara	6.1 – 6.9	6.53	0.3 – 0.57	0.46	0.52 – 0.86	0.75
Kanua	9.9 – 11.6	10.6	0.24 – 0.41	0.33	0.43 – 0.60	0.53
Bot Tola	8.1 – 9.7	8.78	0.19 – 0.3	0.26	0.43 – 0.53	0.49

Table 7: Percentages of soil samples out of 27 samples in different ranges of availability

Parameters	Ranges		
	Low	Moderate	High
Soil pH	Slightly acidic to Alkaline		
Electrical Conductivity	Suitable to all crops		
Organic Carbon	-	44.4 %	55.5 %
Available Nitrogen	25.9 %	74.1 %	-
Available Phosphorus	40.7 %	55.6 %	3.7 %
Available Potassium	7.4 %	92.6 %	-
Calcium	-	-	100 %
Magnesium	-	-	100 %
Available Sulphur	62.9 %	29.6 %	7.4 %
Iron (Fe)	-	77.8 %	22.2 %
Copper (Cu)	14.8 %	70.3 %	14.8 %
Zinc (Zn)	59.3 %	40.7 %	-

Conclusion

The study concluded a good physical condition of the soils. Slightly Acidic to Alkaline soil pH whereas, EC suitable to all crops. Moderate to high Soil Organic Carbon and adequate Nitrogen, Phosphorus and Potassium whereas, low to moderate Sulphur content. Calcium and Magnesium is in high range. Heavy metals such as, Fe and Cu are sufficient while Zn is deficient. Recommended fertilizer doses should be applied as per Soil Test Crop Response to prevent yield losses due to deficiency of nutrients. For better production of the crops and maintain the soil fertility for future cause Integrated Nutrient Management should be adopted.

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