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OBSERVATIONS ON THE EDAPHO-MICROBIAL NATURE OF INDIAN BOTANIC GARDEN, HOWRAH

JAGDISH NARAIN SINGH, MADHAB KRISHNA GHOSH
AND
RATNA SEN
Botanical Survey of India, Howrah

ABSTRACT

The edapho-microbial nature of Indian Botanic Garden was assessed. The activities of Azotobacter were used as an indicator to determine the suitability of edaphic conditions for plant introduction. It was observed that the Hooghly River (Ganga) front had comparatively higher clay content and organic carbon. The water holding capacity, cation exchange ability, pH, porosity and available nutrients such as nitrogen and phosphorus and azotobacter activities of the river site were comparatively superior to the other sites. The middle stretch of the garden area was observed to be more saline than other two stretches. The area towards human settlements was exposed to severe anthropogenic interference. Consequently, the microbial population was diminutive here with relatively inferior edaphic characteristics.

INTRODUCTION

The present environmental turmoil owing to deforestation and acute biotic interference has yielded either complete extinction of many valuable plant species or left many of them on the verge of extinction. In the given context a scientifically maintained botanic garden has a vital role to play in the conservation of horticulturally interesting, threatened or rare species of plant kingdom.

Indian Botanic Garden at Sibpur, Howrah which is situated at the northern flank of the river Hooghly (Fig. 1) has been unique for last two hundred years of its existence as a repository of valuable and rare plant species. The investigations initiated at this Botanic Garden were aimed at finding a basis for scientific management of the garden for further plantations of various endangered and threatened plant species. Bioclimatically the area of the garden is lying within the humid tropic region. The vegetation mosaic of the garden comprised of the introduced tropical and subtropical plants of exotic and indigenous origin. The Flora of the garden, particularly the non-herbaceous species were enumerated (Gage, 1913; Sen and Naskar, 1965). The ground layer vegetation is usually dominated by *Imperata cylindrica* (Linn.) Beauv. and a few common species of weeds and forbs. Some of the characteristic vegetation of the Zones A, B and C (as described in Materials and Methods) are tabled in Appendix I. The monthwise ombrothermic data are given in Fig. 2. The mean annual precipitation is observed between 135-150 cm.

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MATERIALS AND METHODS

With above objective, the garden was divided by two imaginary transects running parallel to the river front (Fig. 1). This was done keeping in view of two dominant interacting factors namely, the impact of Hooghly on one hand and the demographic pressure on the other side of the garden. The area was, therefore, divided into three near parallel stretches (Zones A, B and C) for sampling purposes.

A composite sample was collected from each stretch at depths ranging from 0-20, 20-40 and 40-60 cm. The soil samples were analysed for their physicochemical characteristics and saturation extract properties following the methods as suggested by Jackson (1958) and Piper (1966). The total bacteria content was measured as proposed by Allen (1959) and Azotobacter population as reported in Anonymous (1957).

RESULTS AND DISCUSSION

The range and mean values of mechanical components of soil of the garden are shown in Table-1. The coarse sand ranges from 0.1% to 0.34% and the fine sand and silt components make the major part of the soils. The garden in some part is subjected to occasional high tides during monsoons (Singh and Ghosh, 1985), as a consequence its soil has become comparatively rich in clay contents (28.7%). The remaining part of the garden is usually less clayey (13.9-23.9%). It is significant that there is a distinct distributional pattern of the mechanical component of the garden soils. The sides far from the river front showed less amount of clay and corresponding higher amount of fine sand whereas the sides adjoining the river exhibited the texture otherwise. Such varied status of sand and clay had a direct bearing on the physical properties of soil particularly on the water holding capacity.

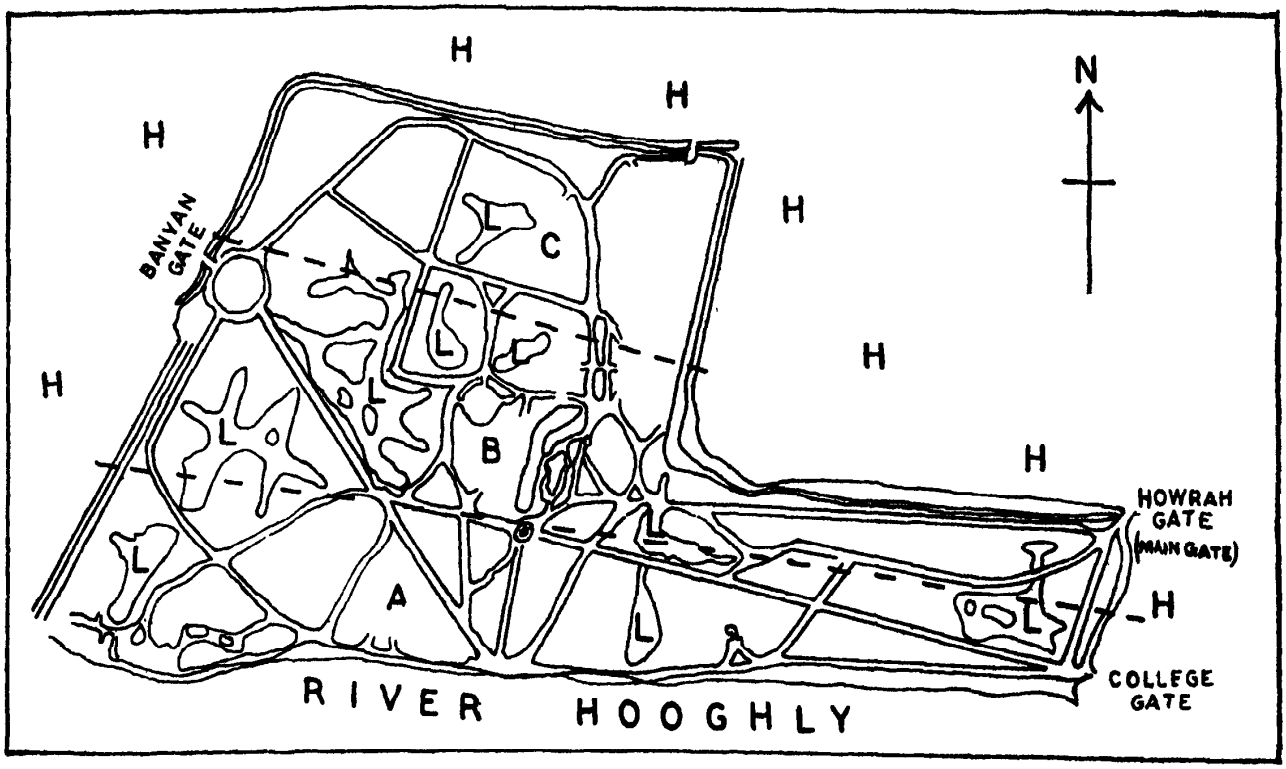


Fig. 1. Plan of Indian Botanic Garden: A, B, C are study stretches from River front, Middle and Far off sides respectively. H. Human habitation. L. Lakes

Table 1 : Mechanical composition of the Garden Soil

(Based on mean value of three replications)

Components	River side area (A)	Middle stretch (B)	Far off stretch (C)
Coarse sand % Range	0.18 - 0.34	0.03 0.12	0.10 0.17
Coarse sand % Mean/SD	0.26/0.022	0.08/0.038	0.14/0.029
Fine sand % Range	25.77 - 36.89	36.2 41.0	39.3 61.0
Fine sand % Mean/SD	32.10/4.661	38.6/1.96	52.2/9.366
Silt % Range	33.8 - 42.7	36.4 37.4	24.2 35.8
Silt % Mean/SD	37.50/3.88	36.8/0.44	28.3/5.31
Clay % Range	26.9 30.7	21.8 26.9	13.9 23.9
Clay % Mean/SD	28.70/1.59	23.9/2.14	18.5/4.12

N.B. SD — Standard Deviation

The soil physico-chemical characteristics with the range and mean values are presented in Table-2. It is apparent here that not only organic carbon but most of the values in Table-2 are comparatively high towards the proximity of the river while the decreasing trend has been noted towards the far off sides. It might be noted further that the surface litter from the garden was frequently removed by the irrational activities of man which in fact has adversely influenced natural regeneration process of soil fertility through humification and mineralisation of these energy materials of garden soil (Singh, 1981). Observations on the field moisture percentage and water holding capacity exhibited their changes due to the impact of textural quality. It can be observed from the data that the river side which is relatively rich in clay content and organic carbon, is also rich in field moisture content (17.6%) and water holding capacity (62.0%). The remaining sides also demonstrated their field moisture contents and water holding capacities according to their clay and organic carbon contents. It is clear from the pH values that the soils are feebly acidic to highly acidic in reaction (pH 4.7—6.2). The available nutrient status for nitrogen and phosphorus is not sufficient enough for the garden soil. However, the river bank side is comparatively rich in these nutrients (0.029% and 0.002% respectively) than other sides of the garden area. Since nitrogen is a vital element for the plant and is not an inherent part of the soil, therefore, its existence in the soil depends on organic matter which can only be improved through scientific management. The phosphorus content, though it is an integral part of the soil but its meagre availability is due to emaciated status of organic carbon and high values of sesquioxide (Singh, 1981). The colloidal activities of the garden soils exhibited through cation exchange capacity. It is clear that the river side has the highest value of the cation exchange (22.2 m.e.%). It is mainly because of higher status of organic and inorganic colloids.

Table 2 : Physico-chemical Characteristics of Garden Soils

(Based on mean values of three replications)

Constituents	River side area (A)	Middle stretch (B)	Far off stretch (C)
Organic Carbon % Range	0.56 1.32	0.16 0.45	0.35 - 0.56
Organic Carbon % Mean/SD	0.87/0.324	0.27/0.127	0.46/0.086
pH Range	5.8 6.7	5.3 6.2	4.1 - 5.2
pH Mean/SD	6.2/0.369	5.6/0.404	4.7/0.450
Available Nitrogen % Range	0.022 0.039	0.025 - 0.28	0.013 - 0.022
Available Nitrogen % Mean/SD	0.029/0.007	0.026/0.001	0.017/0.012
Available Phosphorus % Range	0.002 0.003	0.0018 0.002	0.0014 - 0.0018
Available Phosphorus % Mean/SD	0.002/0.0005	0.0019/0.0003	0.0015/0.0003
CEC* in m.e. % Range	20.3 24.8	18.5 19.6	10.5 - 11.8
CEC* in m.e. % Mean/SD	22.2/1.89	19.1/0.465	11.0/0.54
Field Moisture % Range	13.5 20.6	9.3 14.9	6.2 13.5
Field Moisture % Mean/SD	17.6/2.94	11.5/2.44	9.4/3.022
Porosity % Range	49.1 56.2	49.9 54.5	48.2 56.2
Porosity % Mean/SD	51.6/3.279	52.5/1.925	51.7/3.322
WHC** % Range	58.2 68.2	55.0 57.0	43.1 - 59.0
WHC** % Mean/SD	62.0/4.403	56.2/0.850	51.1/4.775

NB. * CEC — Cation Exchange Capacity
** WHC — Water Holding Capacity
SD — Standard Deviation

Table-3 presents the characteristics of soil solution of the garden soil. The electrical conductivity values clearly demonstrate the solute nature of the garden soil solution which was highest in the middle stretch of the area (EC 3.9 m. mhos/cm). It has been further noticed that the soil solution is dominant in calcium and sodium within cations and bicarbonate and chloride within anions. The carbonate ions were noticed to be conspicuously absent in the soil solution. It has been noticed further that the river side had lesser magnesium in its soil solution whereas the far-off sides were dominated

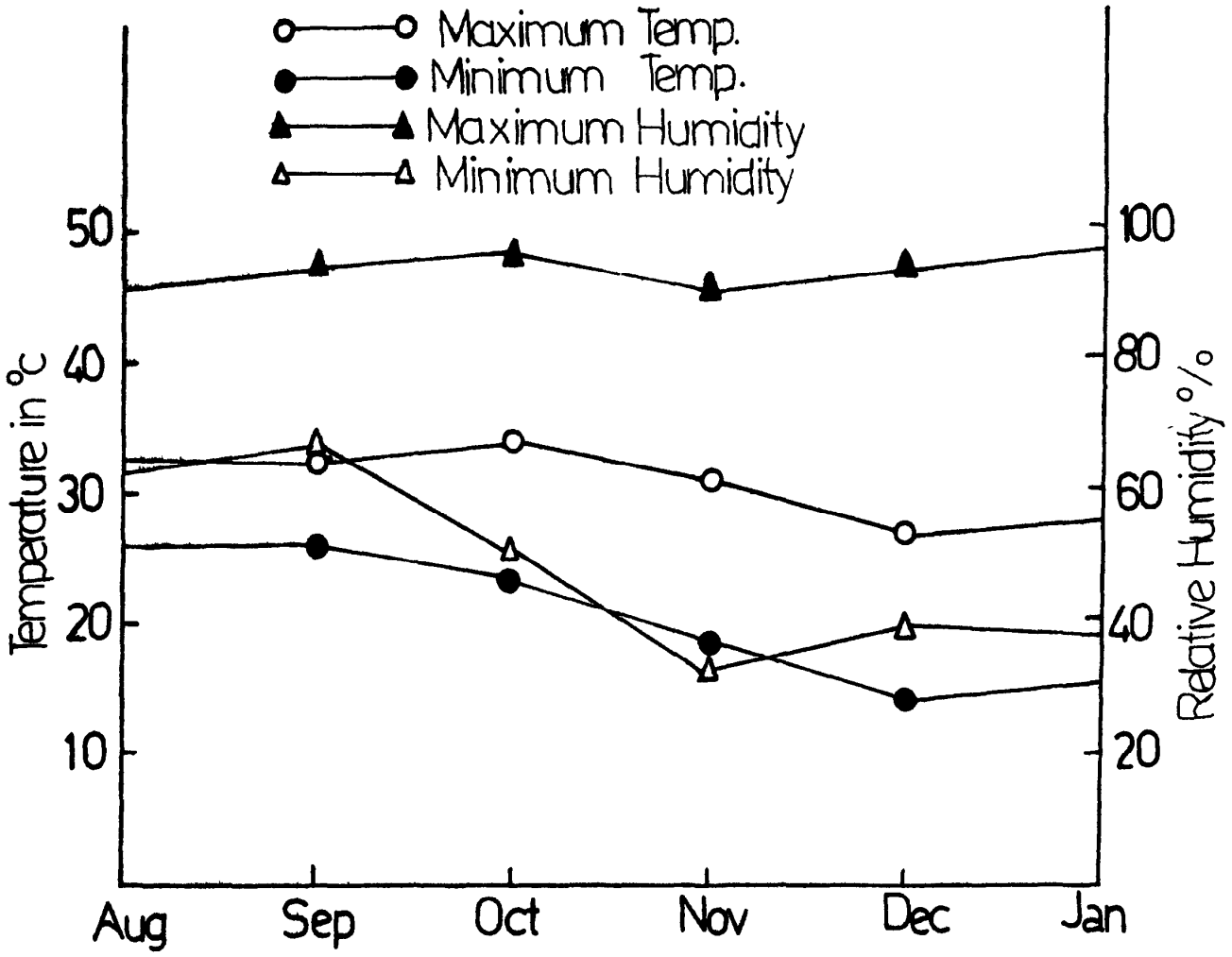


Fig. 2. Monthwise Ombrothermic diagram

comparatively by its higher values. Since magnesium was a vital element and happens to be a component of the chlorophyll, the observation, therefore, was of some significance.

Table-4 depicts the microbial activities of the garden soils. It is apparent from the data that the bacterial presence in the garden soil has insignificant variation in their population whereas the Azotobacter activities were noticed to be associated with definite characteristics of the soil. It has been observed that the river side is the favourable *niché* for Azotobacter activities. The middle and the far-off stretches were noticed for moderate to poor Azotobacter activity. In Table-5 a correlation between important soil properties and the Azotobacter activities have been worked out. The correlation study depict that the Azotobacter has a positive correlation with the organic carbon, cation exchange capacity, field moisture content, porosity, water holding capacity and pH values. But it has been noticed further that it has positive significant correlation only with the cation exchange capacity, water holding capacity and soil pH.

From the results so far analysed, a distinct spatial variation was noted in the garden area owing to the constant interaction of the soil system with the water of the adjoining river Hooghly coupled with the impact of

the demographic stresses and strains within the rest of the area. Owing to direct proximity of the Hooghly, the soils of the garden area along with the river front stretch were rich in clay and organic carbon contents with comparatively favourable soil environment for field moisture, water holding capacity, cation exchange capacity which consequently

Table 3 : Saturation Extract Analyses of Garden Soils

(Based on mean values of three replications)

Constituents	River side area (A)	Middle stretch (B)	Far off stretch (C)
Saturation % Range	34.1 36.6	32.2 35.7	26.6 33.3
Mean/SD	35.6/1.08	34.3/1.529	29.7/2.758
EC in m.mhos/cm at25°C Range	2.7 3.2	1.5 6.5	0.7 1.3
Mean/SD	2.9/0.191	3.9/2.043	1.0/0.245
Concentration in m.e./Litre Ca^{++} Range	4.0 10.0	6.0 18.0	2.0 - 3.0
Mean/SD	7.0/2.449	11.3/4.989	2.5/0.408
Mg^{++} Range	0.2 2.0	1.0 3.0	0.5 - 1.5
Mean/SD	0.9/0.787	2.3/0.943	1.1/0.432
Na^{+} Range	2.5 12.8	0.75 12.5	0.75 2.6
Mean/SD	6.8/4.386	6.2/4.819	1.6/0.742
K^{+} Range	0.60 - 0.65	0.25 0.33	0.32 0.37
Mean/SD	0.63/0.022	0.29/0.033	0.35/0.022
HCO_3^- Range	5.0 7.0	3.0 - 6.0	2.5 3.5
Mean/SD	6.0/0.816	4.6/1.249	3.0/0.408
Cl^- Range	7.5 10.5	5.5 26.5	2.0 3.0
Mean/SD	8.3/1.363	14.8/8.731	2.5/0.408

EC = Electrical Conductivity
SD = Standard Deviation

Table 4 : Microbial Characteristics of Garden Soil
(Based on mean values of three replications)

Constituents	River side area (A)	Middle stretch (B)	Far off stretch (C)
Range	10 - 18	9 19.33	7 19.6
Total Bacteria 10^6 per g. Mean/SD	14.4/3.315	14.11/4.218	14.6/5.333
Range	0.66 19.0	0.33 16.0	0.33 6.0
Azotobacter 10^3 per g. Mean/SD	8.9/7.591	7.1/6.579	3.1/2.328
Range	0.006 0.106	0.003 - 0.083	0.005 0.031
Percent of Azotobacter to Total Bacteria Mean/SD	0.053/0.042	0.043/0.033	0.018/0.011

Table 5 : Correlation coefficient between physico-chemical properties and Azotobacter activities of Garden Soil

Components	Mean	Variance	S.D.	Cor.Coff (r)
Azotobacter	5.90	8.94	2.99	—
Organic Carbon	0.48	5.29	0.23	0.369
CEC	16.8	22.18	4.71	0.92*
Field Moisture content	11.7	11.77	3.43	0.56
Porosity	51.6	0.372	0.61	0.49
WHC	56.1	18.06	4.25	0.91*
pH	5.4	0.578	0.76	0.98*

(*) Positive significant correlation at 5% level.

resulted into an excellent *niche* for the Azotobacter activity. The remaining stretches owing to frequent removal of organic materials (soil energy resources) which could have augmented the organic colloidal activities, had an induced imbalance into their edaphic environments. The noticeable loss of energy materials from the garden eco-pedon system has resulted into its poor fertility status which can best be exhibited by the poor Azotobacter activity in the major part of the area covered by the far-off stretches. The garden soils were poor in available nitrogen and phosphorus but better in soil porosity. The soil solution characteristics clearly depicted the high salinity contents of the middle stretch of the garden. It is, therefore, the reason that the salt tolerant species such as *Acanthus illicifolius, Pandanus* spp. and others showed better performance here. For purposes of garden management it is recommended that the anthropogenic activities must be minimised by the enforcement of garden bylaws and the soil system should be enriched by incorporating organic materials which can only bring significant change in the fertility status of the garden for various plantation experiments which are being conducted here for plant introduction purposes.

APPENDIX—I

Species of Non-Herbaceous Flora in zones A, B, & C of I.B.G.

Species	A	B	C
Actinorhytis calappria Wendl. & Drude		+	
Aglaia odorata Lour.		+	
Aiphanes caryotaefolia (H. B. & K.) Wendl.	+	+	
Anogeissus acuminata Wall.			+
Anacardium occidentale Linn.			+
Annona palustris Linn.			+
Aphanamixis polystachya Parker		+	+
Ardisia solanacea (Poir.) Roxb.		+	+
Arenga undulatifolia Becc.		+	
Artabotrys uncinatus (Lamk.) Merrill		+	+
Artocarpus heterophyllus Lamk.		+	
A. lakoocha Roxb.		+	+
Attalea speciosa Martins	+		
Bactris major Jacq.	+	+	
Bambusa affinis Munro	+		
& other bamboo species	+	+	
Borassus flabellifer Linn.	+	+	+
Bauhinia acuminata Linn.	+		
B. corymbosa Roxb.	+		
Bentinckia micobarica (Kurz) Becc.	+		
Barleria cristata Linn.		+	
Bombax ceiba Linn.		+	+
Ceiba pentandra (Linn.) Gaertn.	+	+	
Cinnamomum camphora Nees & Eberm.	+		
Couroupita guianensis Aubl.	+		
Daemonorops didymophyllus Becc.	+	+	
Diospyros montana Roxb.			+
D. microphylla Bedd.			+
D. jenkinsianus Mart.		+	
Desmos chinensis Lour.		+	
Dolichandrone spathacea (Linn. f.) K. Schum.		+	+
Ehretia acuminata R. Br.		+	
Elaeis guinensis Jacq.	+		
Erioglossum rubiginosum (Roxb.) Blume		+	
Fisus benghalensis Linn.	+	+	+
Garcinia xanthochymus Hook.f. ex Anders.		+	+
Gleditschia macracantha Desf.		+	
Goniothalamus griffithii Hook.f. & Thoms.		+	
Haplophragma adenophyllum (Wall.) Dop.	+	+	
Heritiera macrophylla Wall. ex Voigt	+		
Hyphaene bussei Damm. ex Busse	+		
H. dichotoma (White) Furtado	+	+	
H. thebaica (Linn.) Mart.	+	+	
Ixora arborea Roxb. ex Sm.	+		+
Mesua ferrea Linn.	+		
Pandanus spp.	+		
Parmentiera cerifera Seem.	+		
Pterygota alata (Roxb.) R. Br. var. *irregularis*	+		
Ravenala madagascariensis (Gmel.) Sonn.	+		

(List includes a few characteristic species only)

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