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OVERVIEW OF ECOLOGICAL STUDIES ON CONSERVATION AND MANAGEMENT OF PLANT DIVERSITY IN INDIAN BOTANIC GARDEN, HOWRAH

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ABSTRACT

Ecological factors of Edapho-Microbial Nature, Bio-aquatic nature, Chemical nature of Hooghly river waters and their impact on the eco-pedon system of IBG have been analysed and are presented here with the objective to aid in scientific management of this unique Botanic Garden. Emphasis is laid on the seasonal variations in the factors governing the ecology of the garden. The paper is concluded with some suggestions for upkeep of the balanced ecology of Indian Botanic Garden (IBG).

INTRODUCTION

In the present context of environmental degradation and loss of plant diversity in many parts of the world, the role of botanic gardens has become not only vital but very pivotal. The botanic gardens could be utilized, if maintained scientifically, to give an alternate asylum for the threatened or rare species of plant kingdom particularly those plant species which are highly significant from economic, horticultural or botanic point of view from untimely extinction with proper ecological management practices.

The Indian Botanic Garden (IBG) at Shibpore, Howrah has been analysed for various ecological factors *viz.* Edapho-Microbial Nature, Bio-Aquatic Nature, Chemical Nature of Hooghly river waters and their impact on the eco-pedon-system, Mineral potentialities of the leaf litter of a few tree species, Chemistry of a few aquatic plant species, namely *Salvinia molesta* and *Eichhornia crossipes* and their utilization to improve highly degreded acidic soils, Herbage-layer biomass and edaphic status of IBG, alongwith studies on certain important plant species such as Great Banyan tree etc. In the present paper an attempt has been made to synthesize all these analyses at one place which were made part by part as the potent factors of Indian Botanic Garden with the sole objective to upkeep this unique botanic garden ecologically balanced, so it could be managed scientifically for maximum conservation. For better understanding of the structure and function of the Indian Botanic Garden, these factors are described and discussed here as follows :

BRIEF HISTORY OF INDIAN BOTANIC GARDEN

The Indian Botanic Garden is regarded as the oldest in the south and south-east Asia. Though, historically there is no conclusive opinion about the exact date of its establishment. However, it is obvious from the documents that Lieutenant Colonel Robert Kyd established this garden in July 1787. The original name of the garden was company's garden (Company Bagan) which was christened as Royal Botanic Garden in the year 1857 and was further changed to Indian Botanic Garden in 1950.

The founder father of this garden Sir Robert Kyd served it for six years and during his tenure he tried to set this garden as a horticultural nursery for economic and commercial expectation. He grew

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every desirable plant of many countries but most of them did not survive in the climate and soils of Calcutta. The failure of Robert Kyd paved the way for the transformation of this commercial garden into botanic garden by his successor Willium Roxburgh in 1793 who elevated it to a leading centre of botanical research. In later period this garden had to suffer from several set backs by cyclonic effect. It is evident from the historical records that devastation caused by the cyclone particularly in the year 1864 & 1870 was so grave that garden was deprived of all the shades. It was the Sir George King (1871-1897) who, by his masterly plan and herculean labour reconstructed the whole garden and was largely responsible for its present landscape. His botanical astuteness earned the very name and fame of this garden as one of the best botanic gardens of the world.

Presently, 2350 of trees and shrubs species together with several thousands herbaceous plants grow in the twenty five divisions, five glass houses, five green houses and conservatories in the garden. The garden maintains germplasm collections of bamboos (26 species), bougainvilleas (148 cultivers in 3 species), citrus, jasmines (25 species) palms (109 species) and water lilies (30 cultivers in 4 species).

LOCATION OF INDIAN BOTANIC GARDEN

The garden (net area 110 ha.) is flanked on the north of river Ganges (Hooghly) on the west bank at Shibpore within the district of Howrah in West Bengal. It is about 8 km away from Howrah railway station and about 25 km from Calcutta (Dumdum) International Airport.

GEOGRAPHICAL SITUATION

Geographically, IBG is situated at 22° 35' N latitude and 88° 21' E longitude at the elevation of 4.6 m high from the sea level. The three boundaries of this garden are surrounded by a dense urban settlement except the limit infringed by the river Hooghly about 1.8 km. The morpho-environmental features of IBG lie on an average height of 2.5 m from the water level of the river Hooghly.

CLIMATIC CONDITIONS

Bio-climatically, the IBG falls under humid tropic zone. Singh *et al.* (1990) have presented month wise ombrothermic data on IBG. On an average the temperature ranges between 21°C to 32°C of which the minimum occurs in the months of Dec./Jan., and the maximum is found in the months of April/May. The mean annual precipitations range between 135 to 150 cm (minimum in Nov. to January and maximum in July./Aug.).

BIOTIC AND ABIOTIC PRESSURES ON IBG

The garden has been unique for the last two hundred years of its existence as a repository of valuable and rare plant species. But the evidences proved that this garden did not have its smooth sailing either in the past or in the present and had always been under the influence of tremendous biotic and abiotic pressures (Singh & Ghosh, 1985 and 1987). It may be evident from the fact that there is a dense urban settlement surrounding its three boundaries except the limit infringed by the river Hooghly. The river too has its concomitant impact on the garden. It is faced with a problem of flash flooding and occasional tidal bores during monsoon (July-Aug.) which inflicts noticeable damages on the flora and habitat system. Besides natural encroachment of river waters during monsoonic period, it is allowed to enter inside the garden area during post monsoon period and to occupy nearly 1/9th of the total garden area in the form of twenty five big and small lakes of varying dimension and dispositions. All the lakes are interconnected by an operational subterranean flushing system linked with the river on the south-east. The characteristics of these localized water-bodies that are fed normally with the river water and their consequent ecological implication on the IBG due to assumed riverine effects are noted. Under biotic interference the garden faces severe stress not only from without where dense human settlements are there along its three boundaries but from within too, as it is apparent from the fact that a large army of garden curitorial force maintained the regular practice of manicuring the herbage layer.

EDAPHIC CHARACTERISTICS

In general, the soils of IBG have been described to be gangetic alluvial. Under ecological programme the edaphic nature of IBG have been studied physico-chemically not only for the surface soils but sub-surface too, by dividing the IBG into three segments across the gradient running parallel to river front (Singh, 1979, and Singh *et al.* 1991). It was done keeping in view for two dominant interacting factors namely, the impact of Hooghly river on one hand and the demographic pressure on the other side of the garden. A general sum-up on the physico-chemical characteristics of the garden soils are as follows :

Mechanically, the garden soils are made up of fine sand and silz as their major components. About 74% to 83% of these soils are composed of these elements. The course sand quantum has been observed to be less than 1% for all the soils either of surface or subsurface levels. The amount of clay in the soils is variable. The portion of garden along the river front is subjected to occassional high tides during monsoon (Singh & Ghosh, 1985) and as a consequence its soils have become comparatively rich in clay content (29%). But the remaining parts which are far from river front are observed to be comparatively low in clay content (14%-24%). Thus, a significant distinction has been observed in the distributional pattern of mechanical components of the garden soils. The areas away from river front are less clayey with higher amount of fine sands whereas the areas adjoining to the river exhibited the texture otherwise. It was further observed that in the sub surface soils the amount of clay increases with increase in their depths.

Under Physico-chemical characteristics the soils of IBG, in general are feebly acidic to moderately acidic in reaction (pH 5.2-6.5). It was also observed with interest that the values of organic carbon which are supposed to be the back bone of any soil are very meagre. Consequently the other vital nutrients such as available nitrogen and phosphorus are also affected by such characteristics. For surface soils the value of organic carbon is comparatively higher whereas its amount is significantly found to be decreased with the increase in the level of depths. The soils in proximity to river front contain comparatively higher content of organic carbon whereas the decreasing trend has been noted in soils of the areas away from the river bank. In general the soils of IBG have been observed to be very much bereft of organic carbon.

Observations recorded for field moisture contents and water holding capacity of IBG soils exhibited their pattern in accordance with the pattern of clay and organic carbon present in the soils. It has been seen that 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%) (Singh *et al.* 1990). A similar pattern for cation exchange capacity has been noticed in IBG soils. The values of bulk density, parcticle density and porosity of IBG soils are moderate. Observation on soil solution of these soils showed high solute pressure of the middle stretch (E.C. 3.9 m. mhos/ cm on 20°C). It was further observed that soil solutions are dominant in Calcium and Sodium within cations and bicarbonate and chloride within anions. The carbonate ions have been noticed to be conspicuously absent in the soil solution of these soils. It has been further noticed with interest that river side has lesser magnesium ion in their soil solution whreas the far off sides are dominated comparatively by its higher values.

WATER REGIME OF IBG

Due to perennial continuous flow of river Hooghly, the garden area is quite rich in water content and it can fulfill any amount of water requirement needed for its flora & fauna. Besides the stretch of river Hooghly (1.8 km). On one side, the garden has twenty five big and small lakes inside. During monsoon the river water sometimes overflows and fills (innudating) a large area through tidal bores and inflicts grave damage to the flora, fauna and the habitat system of IBG. In the course of ecological studies of IBG, the chemical nature of Hooghly river water, lake water and soil saps were thorughly studied and it was found that river water was extremely poor in mineral contents over lake water or soil saps. Maximum salinity of river water

(E.C. 810 micro-mhos/cm on 20°C) was recorded in the month of May whereas the concentration gradually decreases from July onwards, and the values remain static till December. An increasing trend is further noticed from January onwards. It was clear from the analyses that river waters are not much saline but exhibit alkaline nature as evident from its pH values (pH 7.5 to 8.9 with mean value 8.3). The waters as a whole were calcium dominant. Their cations & anions as per dominance were Ca^{++}> Na^{++}> Mg^{++}> K^{+} (For Cations) and $HC\bar{o}_3$> Cl–> $C\bar{o}_3$ _ (For anions).

The lakes which predominantly hold water from the river Hooghly, however, exhibit different chemical characteristics which vary according to disposition of lakes within IBG (Singh & Ghosh, 1988). Observations on chemical characteristics of nine big lakes reveal that each lake was different from the other in their quantitative and qualitative nature. A salinity sequence of these water bodies was prepared on the basis of mean annual electrical conductivity (EC) values in the order of Sadir> Leram> King> Dhobi> Prain> Janaradan> Kunstler> Scortechin> Diwan lake. The lake waters were mainly alkaline in reaction (pH 8.3 to 8.7).

The chemical nature of water of river Hooghly interferes certainly with the chemistry of the lake waters but it does not appear to be a dominant factor. For example Cl– range of Sadir lake (quite adjacent of river Hooghly) was between 6.0 m. e./L. to 25.5 m.e./L. whereas the river water showed a maximum Cl. concentration of 0.75 m. e./L. which is just beside of the Sadir lake. It was further noticed with interest that lake water had free residual carbonate.

SOIL MICROBIAL FACTOR OF IBG

Under soil microbial studies of IBG, the soils were studied for total bacteria and azotobacter population (Singh *et al.* 1990). The azotobacter population was taken as an indicator to understand the fertility status of IBG soils. It was observed that bacterial presence in IBG had an insignificant variation in their population whereas azotobacter activities were noticed to be associated with definite characteristics of the soils. It was observed with interest that the river side was the most favourable niche for azotobacter activities, while the middle and far off stretches were noticed for moderate to poor azotobacter activities. When a statistical co-relation between important soil properties and azotobacter activities was worked out it was found that azotobacter had positive co-relation with organic carbon, cation exchange capacity, field moisture content, porosity, water holding capacity and pH values. But it was noticed with further interest that it had positive significant co-relation only with cation exchange capacity, water holding capacity and soil pH.

A RELEVEANT ASPECT OF HERBAGE AND NON-HERBAGE FLORA OF IBG

Singh & Ghosh, 1991 have recorded a periodical incidence of herbage/species in IBG. This study was aimed to understand the garden system potentiality towards production of renewable resources of energy materials. It was observed that *Imperata cylindrica* (L.) P. Beauv., was the major constituent of herbage layer. It was further noticed with interest that the root biomass ratio of the layer was higher than the shoot biomass. The total biomass production was at its Zenith during the months of October and November. For the maximum production of total biomass 16%-20% field moisture was observed to be optional under garden condition. But a decrease in soil moisture from 16% to 13% significantly affected the shoot/root production. Moreover, an increase of field moisture from 20% onwards significantly affected and growth of root biomass. It was further observed that from the months of Sept. to Dec. roots, moisture was found to be higher than the shoot moisture whereas it was found to be lesser from January onwards. It was also observed with interest that constant removal of phytomass (energy materials) from the herbage layer on account of anthropogenic activities had created imbalances on the corresponding edaphic characteristics.

Singh *et al.* (1990) have presented a brief list of non-herbage phanerogams in cultivation in the IBG. The morpho-environmental feature of IBG is situated about an average height of 2.5 meter from the mean level of river water and is characterised by an uniform mat of grassy communities dotted with the introduction of exotic and indigenous plants mostly of perennial under-shrubs and trees. It was noticed with interest that characteristic feature of these introduced tall tree species have their root system superficial in the soils of IBG and as a result they are highly succeptible to high velocity winds (hurricane) and get easily uprooted.

A RELEVANT ASPECT OF AQUATIC FLORA OF IBG

Singh & Ghosh (1988) have presented a mean annual incidence of vegetation communities such as free floating, rooted submerged, semi-emergent and amphibious in nine important lakes of IBG. It was observed that the disposition of lakes *vis-a-vis* temporal changes accompanied by human interferences were the responsible factors affecting the floristic composition of these water bodies for their proper conservation. It was further observed that the Sadir lake with high mineral contents harbours communities of *Lemna-Pistia, Hydrilla-vallisneria* etc. Since Lakes were subjected to acute human interference and it was very difficult to categorise the communities strictly according to their salt tolerance capacities. However, a reflection of such aspect was observed, for example the common species like *Pistia, Hydrilla* and *Vallisnaria* etc. could thrive well in extreme range of electrical conductivity between 0.49 m. mhos/cm to 6.8m. mhos/cm and between varied range of soluble sodium percentage (SSP) and sodium absorption ratio (SAR) from 38 to 80 and 1.8 to 8.7 respectively. The species of *Eichhornia* though, seemed abundant in the Prain lake with *Salvinia* and floating mass of algae which was maintained for the culture of Nelumbo species where EC was in between 1.4 to 4.3 m. mhos/cm; SAR 2.4 to 7.7 and SSP 45 to 68; but the species is conspicuously absent when salinity values were greater as observed in Sadir Lake.

While working on body chemistry of *Salvinia molesta* and *Eichhornia crassipes*, Singh & Ghosh (1983) have observed that these two communities together formed an immense measure of phytoplanctonic potential. With a R & D orientation programme these green potentialities–as chemical reserves were studied in different conditions. They could well be utilized as dry matter with or without tricalcium phosphate for correcting highly degraded exceptionally acidic soils (Ph 3.0).

MINERAL ECONOMICS OF IBG

In the conservation of the bio-physico-chemical matrix of an environment, the role of mineral components is very pivotal. The mineral contents of IBG are getting lost by two ways. Firstly, by direct or discernible loss of mineral matter—it was noticed in course of ecological studies in IBG that a large quantity of valuable minerals which were locked up in the fallen leaves and other parts of plant bodies of both terrestrial or aquatic types are being cleared off from the surface of the soils or water bodies mannually on a regular basis manicuring the garden area. Singh & Ghosh (1985) have assessed the loss of various nutrients from the terrestrial leaf litter in term of kg/tonne. However, a similar loss is also there from aquatic flora which had not been taken into account. On an average the eco-pedon system of IBG was losing nearly 89 kg of ash, 376 kg carbon, 25 kg of nitrogen (the carbonaceous substance if incorporated in the soil it could have fixed an additional amount of 15 kg of nitrogen through photochemical means, hence the total loss of nitrogen was 40 kg), 5.49 kg of phosphorus 34.2 kg of calcium, 4.46 kg of potash and 3.9 kg of sodium per unit tonne of leaf litter. Secondly, the garden system was incurring loss of valuable minerals by indirect or indescernible process of natural forces acting upon garden area. During monsoonic period the Ganges water sometimes overflowed and spread within large portion of the garden and stagnated for several days. Such loss due to flash flood has been quantified by Singh & Ghosh (1984) and it was observed that Ganges water contained lesser concentration of dissolved minerals with pronounced sodium activities. Evidently therefore, the mineral riches of soil system is being lost due to contact with dilute river water and consequently straining the soil system to the salt imbalances in the process. It has been noticed that a week long stagnation of river water siphoned off nearly 1/3rd minerals from soils in the vicinity of the river, whereas soils located away from the river lost approximately half of its total soluble salts. It was further observed that if stagnation of waters continued for another one week, the soil system would further be deprived of its soluble minerals equivalent to an EC (Electrical conductivity) of 100 Micro mhos/cm. Thus, the garden soil system is very succeptible towards indiscernible mineral loss in the direct contact of Ganges water.

DISCUSSION

The various factors which were studied in connection with the better ecological management of IBG revealed that the garden needed an extra care for its seasonal variations. For selection of the site of this garden, its founder father Sir William Kyd, might have probably been attracted for two vital factors first, the availability of free water, as river Hooghly a perennial source of water flows constantly at its one margin and second, its fertile alluvial soil under moist tropical climate. However, his imagination received a severe jolt when he found that his majority of the commercial plantations which were brought from all over the globe were wilted under existing conditions of West Bengal (Dev, 1977). The probable reasons may be attributed to the fact that the moist tropical climate under which this garden falls has its own peculiar affect. The characteristics feature of such climate might add some genuine stress and strain on garden area owing to the fact that under such environment a large quantity of valuable minerals is locked up in the leaves and other parts of plant bodies, whereas its soils remain very poor in energy materials and valuable mineral elements due to quick oxidation by the high temperature and simultaneous, leaching of minerals due to heavy precipitations prevalent under these environment.

After climatic factor, the second vital factor is considered to be its soils. It is alluvial in nature and apparently looked very fertile. But a systematic analyses of these soils for their mechanical make up and some vital physico-chemical characteristics and biological characteristics revealed that these soils are mainly composed of inert particles i.e. fine sands & silts. Together these two particles occupy nearly three forths portion (76% to 80%) within mechanical components of the soils. The presence of such inert particles as the major components in a soil system yields very loose soil-structure and consequently, its anchorage capabilities are found to be extremely poor. Observations taken on non-hebaceous flora, particularly the higher trees which are very much succeptible to high wind velocity and get easily uprooted may be explained due to presence of such textural and structural composition of the IBG soils. The other probable reason for easy uprooting of especially tall large crowned trees may be attributed due to higher water table of the ground water within IBG area which inhibits the formation of deep root system. On an average the level of ground water in the garden is the same (approximately 2.5 m) as the level on which river Hooghly is flowing. It is therefore, reasonable that either hydraulic pressure is not allowing the major root system of these higher trees to penetrate deep into the soil system or these tall vascular trees may be getting their water requirement fulfilled from the surface soils and thus, not developing their root system deeper in the soils.

Other very vital characteristic of IBG soils which get affected by the present practice of the garden is its organic carbon status. The frequent and quick removal of phytomass from garden area has left garden soil system bereft of energy materials. The emaciated value of organic carbon has not only created imbalances within soil system but has badly affected the other equally important soil characteristics such as water holding capacity, porosity, cation exchange capacity etc. Observations taken on low content of macro nutriants such as nitrogen and phosphorus in this soils of IBG may be attributed to the fact that nitrogen is not and integral part of soil system. Its values totally depend on the presence of organic compounds available in the soils in the form of soil energy materials. Secondly, the other macro-nutrient i.e. available phosphorus, though it is an integral part of the soils but in IBG soils it gets fixed due to presence of high values of sesquioxides which are prevalent in the garden soil system and simultaneously lack of sufficient content of organic materials.

In microbial studies, Singh *et al.* 1990 had used the azotobacter population as an index to understand the fertility status of the garden soils. Results on azotobacter clearly indicate that owing to direct proximity of the river Hooghly, the soils of garden area along the river front are rich in clay and organic carbon contents with comparatively favourable soil environment for field moisture water holding capacity, cation exchange capacity which consequently give rise to an excellent niche' for the azotobacter activities. The remaining stretches owing to frequent removal of organic materials (Soil energy resources) which could have augmented the soil's organic colloidal activities, had an induced imbalance into their edaphic environment. The noticeable loss of soil energy materials from the garden eco-pedon system has led to poor fertility status which exhibited by the poor azotobacter activities in major parts of the garden area.

The effect of water regime on garden area may be noticed in two ways. Firstly, in the form of free water & secondly, as the ground-water. As free water it enters in the garden area in various lakes as well as occasional tidal bores during monsoonic period (July-Sept.). Contrary to the effect of innundation through tidal bores which has been described within the affect of free water in the form of lakes is different. It is noted with interest that the same river water creates ecologically divergent aquatic environment in different lakes according to their dispositions and as a result owing to the inherent diversity of lakes a significant incidence and abundance of various aquatic plant communities take place in the various lakes (Singh & Ghosh, 1988). The impact of ground-water has already been discussed in relation with higher non-herbaceous flora of IBG.

The noticeable observations taken on herbage layer biomass where it was found with interest that root biomass was always measured to be higher than the shoot biomass in time and space adequately demonstrated the highly disturbed condition of IBG by the biotic agency. Though, the underground biomass was not directly influenced by the ground operations but it appeared that the disturbances in the shoot layer caused adverse effect on the under ground biomass. A statistical calculation on inter-relationship between root and shoot moisture with soil moisture demonstrated their positive correlation ($r = 0.97$) which signalled in negation with present garden practice of unjudicious removal of phytomass from the soil system without alternative arrangement. To get optimal field moisture quantum i.e. 16%-20% on which the garden soil system produced the maximum biomass needed positive enhancement in the colloidal activities of the garden soils which was only possible through incorporation of soil energy materials with tricalcium phosphate combination. This combination may produce stable carbonaceous and nitrogenous compounds in the soil system and thus, enhance its colloidal activities. The leaf litter analyses of individual tree species adequately exhibited their specific nutrient contents, for example *Polyalthia longifolia* contained highest values of organic carbon (41.1%) and potash (0.634%), *Ficus benghalensis* possessed, ash. (15.4%) and calcium (6.0%), *Butea monosperma* had nitrogen content (3.36%), *Dillenia indica* had ash (19.8%) etc. Under garden management these individual tree leaf litter may be used in nursery for raising specific seed bed for specific plant species in accordance of their need & requirements.

CONCLUSION AND SUGGESTIONS

Based on the analyses of the ecological factors in IBG and discussion made on it, it may safely be concluded that IBG needed utmost care in its handling due to presence of negative forces at its four boundaries in the form of biotic and abiotic factors and fully enveloped by the non-friendly climatic conditions (Moist humid trophic). Since there is no control over natural forces, it is, therefore, desired that under scientific management of IBG main emphasis may be laid on its soil and water managements along with suitable amendments which are required to be brought in the traditional practices being operative in the maintenance of IBG.

Under soil management, it may be noted that major portions of mechanical composition of IBG soils are made up of inert components *viz.* fine sands and silts and thus, soils are yielding an unstable soil structure and consequently resulting into meagre soils anchorage characteristics. Besides, these mechanical defect, IBG soils are chemically rich in sesquioxides and vehmently poor in organic carbon. These two chemical parameters which are diagonically opposite to each other have yielded many odds in the soil system. The rich sesquioxides minimise the availability of soil phosphorus quantitatively and poor organic carbon reduces the availability of nitrogen content and significantly decreases the soil colloidal activities. As a result soils performances towards water holding capacity, porosity, cation exchange capacity and field moisture contents are significantly affected. The aforesaid soil defects are further confirmed by azotobacter studies on fertility status assessment of IBG soils because these asymbiotic bacteria have close relationship with such soils characteristics. Since sesquioxides content of the soils is inherent characteristics of the *insitu-soil,* however, its impact may be counteracted to maximum extent alongwith other defects of soils arising out due to meagre presence of organic carbon through incorporation of energy materials in the IBG soils. But, if energy materials are incorporated alone in the soils, it may readily be vanished from the soil system due to high temperature available under prevailing climatic conditions of the area. It is, therefore, strongly reccommended that these materials must be mixed up with the suitable quantity of tricalcium phosphate with proper ensurance of water supply in the soil system. Due to presence of phosphate, highly stable compounds such as phospho-proteins may be formed in the soils which may adequately improve the soils physico-chemical characteristics. The IBG premises contain an immense measure of carbonaceous substances (energy materials) which are generally misused in the garden. It is, therefore, suggested that these huge amount of phytoplantonic biomasses may be duly utilized purposefully not only for augmenting fertility status of IBG soils system but could be exploited with a R & D orientation programme as the natural source of chemical reserve in serveral contexts.

Under water management it may be suggested that an adequate arrangement may be made for complete check of overflow of river water during monsoonic period inside the garden area. For this, the embankment area of the river front may further be raised. It was the master-plan design of Sir George King who excavated twenty five lakes inside the garden area and their soils were used for elevating water front side during his tennure 1871-1897. But due to elapsed of time the soils erosion caused at water front side as well as within garden area, thus, resulted into low embankment level and gradual shallowing of the lakes surface. It is, therefore, suggested that exhisting lakes may further be deepened and their soils may be utilized for raising river front side. Besides, these mechanical arrangement some biological measures may be adopted for curtailing water hazard arising due to overflow through plantation of mangroves species at river front side alongwith plantation of some bamboo species which are anti-soil erosion. For neutralising bad impact of high water table of garden area, which are resulted into easily uprooting of higher tree species due to shallow root system, it may be suggested, that mechanical pressure should be provided to the higher trees species by putting adequate soils at surrounding their trunk. The impact of high water table may further be reduced through increasing biotic density per unit area of this garden specially with those species whose water requirement is high & simultaneously are deep rooted.

The river waters which are allowed to enter inside the garden area under various lakes, it is suggested, that the heterogeneity created in the bio-aquatic environment of the area due to disposition of the gardens waterbodies may be preserved for getting divergent nature of aquatic floras. These natural diversities are further accentuated due to seasonal cycles but negatively aggravated due to regular interference of man's activities. Hence, for proper conservation of these aquatic environment of garden's water-bodies the biotic interferences must be minimised and the inherent heterogeneity must be rationally utilized for aqua-culture of species demanding favourable media which are available in plenty here in these lakes.

Besides, above measures and precautions which are highly essential towards proper conservation of

IBG, there are certain serious activities which are generally overlooked by the garden's managerial wing but inflict very unhealthy impact on the garden's body. For example, on occasion of significant national days, say, 26th January, 1st January (change of year) or days pertaining to communities festivity, the garden is flooded with human bodies and its appearence is thoroughly changed from a botanic garden to a public picnic garden. The IBG is the only example in this respect in the world. So, it is strongly recommended that the very botanic nature of this garden must be preserved at any cost.

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