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CHEMICAL NATURE OF HOOGHLY (GANGA) RIVER WATER AND AN ASSESSMENT OF THEIR IMPACT ON THE ECO-PEDON SYSTEM OF INDIAN BOTANIC GARDEN, HOWRAH

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ABSTRACT

The eco-pedon system of the protected premises of the Indian Botanic Garden, located along the river Hooghly in the lower gangetic plain in the district of Howrah, has been studied with a conservational point of view to understand the indiscernible phenomenon of the impact of the river water on the garden eco-pedo-chemical characteristics often submerged due to occasional tidal inundations of the river during the monsoons.

It is experimentally revealed that a chemically dilute river water siphons off the mineral riches of the submerged soil system during flash floods. The intensity of mineral erosion is noted to be directly proportional to the periodic length of submergence of the soil system notwithstanding its natural revamping capacity.

INTRODUCTION

The Indian Botanic Garden (IBG) is located along a stretch of 1.8 km of water front on the northern flank of the river Hooghly in the lower gangetic plains of Howrah district in West Bengal. The area, now 110 ha. net, has long been thought to be ideal environment for its conservation as a unique repository of living plants in India, is faced with a problem of flash flooding. The morpho-environmental features of the area, lying about an average height of 2.5 m from the mean water level of the river, are characterised by an uniform mat of grassy communities dotted with the introduced exotic and indigenous plants mostly of perennial undershrubs and trees and a mosaic of twenty five lakes of varying dispositions which comprise $\frac{1}{8}$ th of the total area of IBG. The lakes are interconnected by an operational subterranean flushing system linked with the river on the south-east. The characteristics of these localised water bodies that are fed normally with the river water and their consequent ecological implications on the IBG due to assumed riverine effects are noted. Initially, the chemical characteristics of the river water available in these lakes depending on their proximity from the river front, are studied for the primary changes in their chemical status. The impact of such changes is found to be significant in the development of a garden aquatic flora. The primary chemical characteristics of the river water are determined now only in the present investigations.

In recent times the hazards such as the tidal floodings have overtaken the garden with the rising of water level of the river Hooghly during monsoons. In the flood of 1978 the river water stood between an average height of 1.5 m on the garden surface for more than couple of days. The damages were enormous in terms of the plants lost by the gush of flood water and subsequent waterlogging of the soil system. In view of the possible changes in the eco-pedological status of the affected soils the investigations are initiated to establish the indiscernible phenomenon of the soil environment under

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the stresses of submergence. The phenomenon has been studied in the ecology laboratory with a view to apply more rational strategy for the conservation of the garden habitat system.

METHOD AND MATERIAL

The Hooghly river water is analysed, out of a composite sample (0-15 cm depth) bottled each month of the year 1978/1979, for calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, pH and electrical conductivity values.

The representative soil samples are collected from the immediate vicinity of the river and further away from it for the purposes of experiment with the sampled river water.

Each soil sample is analysed for pH. The sampled soils are first saturated with the distilled water and the saps extracted for chemical standardisation. The experiments are set up with each set of 300 gm of sampled soil put separately in 1-litre beakers and kept them submerged with 500 ml of Hooghly river water collected in the month of August (monsoonic period) and allowed the experiments to remain as such for given spans of time. After allowing the waterlogging for a period of 7 and 15 days, each set is analysed for its supernatant contents followed again by similar analyses for their leachates. The respective leachates are collected after the supernatant liquid is drained out of the experimental sets of the soils. The above treated soils are allowed to air dry at the end. The saturated extracts of these samples are collected later with the distilled water and finally analysed for the given components. The standard techniques are followed for the chemical analyses in the present work.

RESULTS AND DISCUSSION

The chemical characteristics of the Hooghly river water are presented in table 1 and in figures 1 and 2a, 2b & 2c. It is clear from the analyses that the Hooghly water is not much saline but exhibit alkalinity as evident from its pH readings. The dominance of individual cations and anions are apparent in the mean annual values and in the chemical components (Table *l.c.*). The ions can be arranged as per dominance, such as the cations : $Ca^{++} > Na^{+} > Mg^{++} > K^{+}$, and anions : $HCO_3^{-} > Cl^{-} > CO_3^{--}$

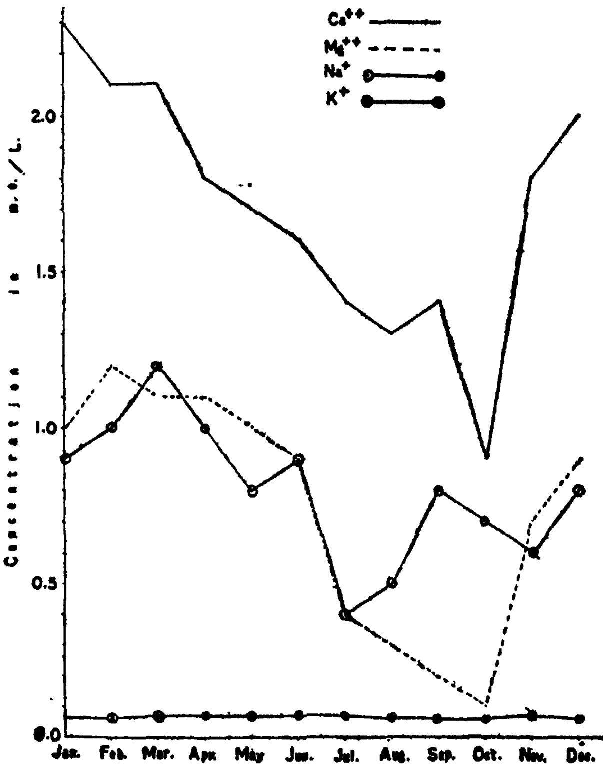

FIG. 1 Monthwise cationic variations in Hooghly river waters.

The monthwise cationic variation of the Hooghly water are given in figure 1. The graphs demonstrate the maximum and minimum cationic concentrations along the various period of the year. It is apparent from the curves that Ca^{++} and Mg^{++} have close resemblance, while Na^{+} showed erratic variation in its concentrations. The K^{+} maintained its insignificant variation throughout the year.

The anionic variations of the river water are presented in figure 2a. The maximum and minimum concentrations for each anion are also apparent from the individual curve along with various period of the year. It is noticeable further that the carbonate ions are present from December to May but their presence are either merely qualitative or even absent for the remaining period of the year.

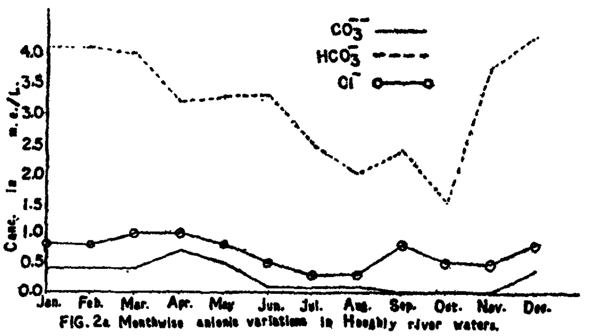

FIG. 2a Monthwise anionic variations in Hooghly river waters.

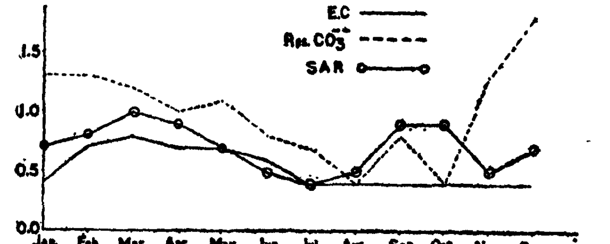

FIG. 2b Monthwise variations in EC (millimhos/cm.), Residual carbonate (m.e./L) and Sodium adsorption ratio (SAR).

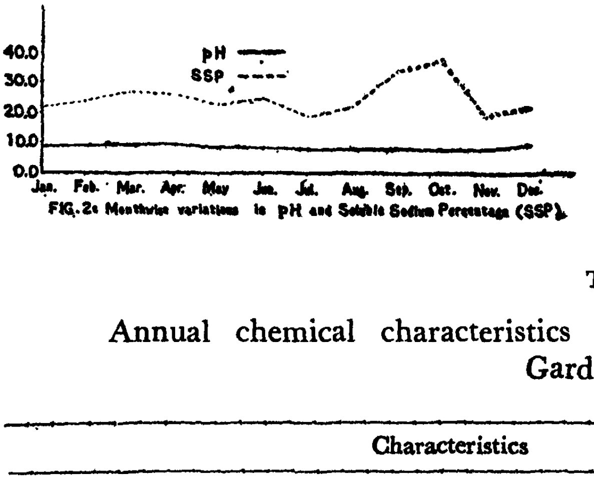

FIG. 2c Monthwise variations in pH and Soluble Sodium Percentage (SSP).

The quantitative and qualitative relationship of the river water constituents are demonstrated in figures 2b & 2c. It is distinct from the EC curves that maximum salinity (EC=810 micro-mhos/cm) of water is found in the month of May whereas the concentration is gradually falling towards July from where the value remains static till December. An increasing trend is further noticed from January onwards. It is apparent from the curves of EC and SAR that the trend in the phenomena is similar to each other excepting during monsoon when the concentration of the water-gradients remained nearly static, the SAR and SSP values are marked by higher trends. The phenomenon is attributed to the fact that the activities of the sodium ions become highly prominent during this period over other cations. The residual sodium carbonate and bicarbonate curves are similar as evident from the graphs.

The impact of river water on the submerged garden soil environment during flooding is experimented with and the results are shown in figures 3 (a, b & c) and table 2. The experimental water sample from the river has the EC value of 435 micro-mhos/

TABLE 1

Annual chemical characteristics of Ganga Water Station : Indian Botanic Garden, Howrah

	Characteristics	Range	Mean
Concentration in m.e./L	Ca^{++}	0.930—2.300	1.690
	Mg^{++}	0.120—1.150	0.730
	Na^{+}	0.420—1.180	0.790
	K^{+}	0.062—0.072	0.065
	CO_3^{--}	Trace—0.700	0.230
	HCO_3^{-}	1.480—4.250	3.200
	Cl^{-}	0.250—1.000	0.650
EC in micro-mhos/cm at 25°C		398 — 810	544
	pH	7.5 —8.9	8.3
	SSP	18.91 —38.23	25.16
Residual CO_3^{--} in m.e./L		0.40 — 1.80	1.00
	SAR	0.446— 0.983	0.72

TABLE 2

Chemical characteristics of the treated soils and water

Supernatants Soils Leachates	Chemical characteristics		
	pH	EC micro-mhos/cm at 25°C	Residual CO_3 m.e./L
FRESH GANGA WATER	8.3	435	0.40
Supernatants after 7-days :			
Sample-I	8.6	800	0.30
Sample-II	8.8	900	—
Supernatants after 15-days :			
Sample-I	9.0	1000	0.20
Sample-II	9.3	1200	0.10
BOTANIC GARDEN SOILS :			
Sample-I	6.4	1200	—
Sample-II	6.8	1500	—
B. G. Soils after 7-days of treatment with Ganga water :			
Sample-I	6.9	900	—
Sample-II	7.5	800	—
B. G. Soils after 15-days of treatment with Ganga water :			
Sample-I	7.0	800	—
Sample-II	7.6	1200	—
Leachates after 7-days :			
Sample-I	8.2	1050	0.20
Sample-II	9.0	1200	—
Leachates after 15-days :			
Sample-I	8.5	1200	0.60
Sample-II	9.0	1300	—

cm whereas the saturation extract (soil saps) of experimented garden soils have the EC values (EC=1200 and 1500 micro-mhos/cm) which are approximately 3 and 3.5 times higher than the river water. The reaction of the soils under experiment is feebly acidic (pH 6.4 and 6.8) and the soil saps have been characterised by the absence of carbonate.

The supernatant liquids from both the samples reveal that the incorporated water having EC=435 micro-mhos/cm absorbed nearly its equivalent amount of salts from the soil saps within a week (EC=800 and 900 micro-mhos/cm of supernatant liquid). Likewise the samples analysed for determining the quality of supernatant after 15-days of water-logging, it is noticed that with the increase of the duration of submergence of the soil, the mineral solubility potential of the same water remained unabated which is evident from the much enhanced EC values (1000 micro-mhos/cm and 1200 micro-mhos/cm) after the end of the said period. The other important characteristics which have been noticed from the supernatant liquids, at varying span of times in the experiment, are their pH values. The results manifest that the reactions of the supernatant is highly alkaline in comparison to the initial river water used in the experiments of the extracted soil saps, and even the leachates. The free carbonate estimated in the supernatants may be the possible reason for the higher pH values.

Finally the leachates collected from each set of experimental soils after the supernatants are allowed to stand *in situ* for a period of 7 and 15-days duration. The EC values of the leachates showed that the experimental water further dissolved the minerals from the soil during above stated periods such as for 7-days period EC=1050 and 1200 micro-mhos/cm and for 15-days period, EC=1200 and 1300 micro-mhos/cm. It is noticed from the nature of the pH of the leachates that though the pH here is highly alkaline, it is insignificantly less than the pH of the supernatants. From the experiments on the soil it is evident that the soils at the vicinity of the river is susceptible to loosing its ¼ of its soluble minerals (EC varied from 1200 to 900 micro-mhos/cm) whereas the soil sampled away from the river lost nearly half of its total soluble salts content (EC varied from 1500 to 800 micro-mhos/cm). The soil saps of the treated soils after 15-days of stagnation reveal that the soil nearby the water front further lost its soluble mineral contents equivalent to the EC of 100 micro-mhos/cm with its Mg^{++} status well recovered ; whereas, the observations on the effect of stagnation on the soil, away from the water front, revealed that despite the continuous release of minerals in the supernatant and the leachates, a significant recovery of half of its lost minerals (EC enhanced from 800 to 1200 micro-mhos/cm). The variations in the recovery of mineral status in both the soils may be explained by differential inherent mineral recovery potentials of these soil located near and far from the river front. It appears, therefore, from the observations that due to constant contact of the garden soils facing the river water at the proximal end, affect the mineral revamping capacity of the water front soils.

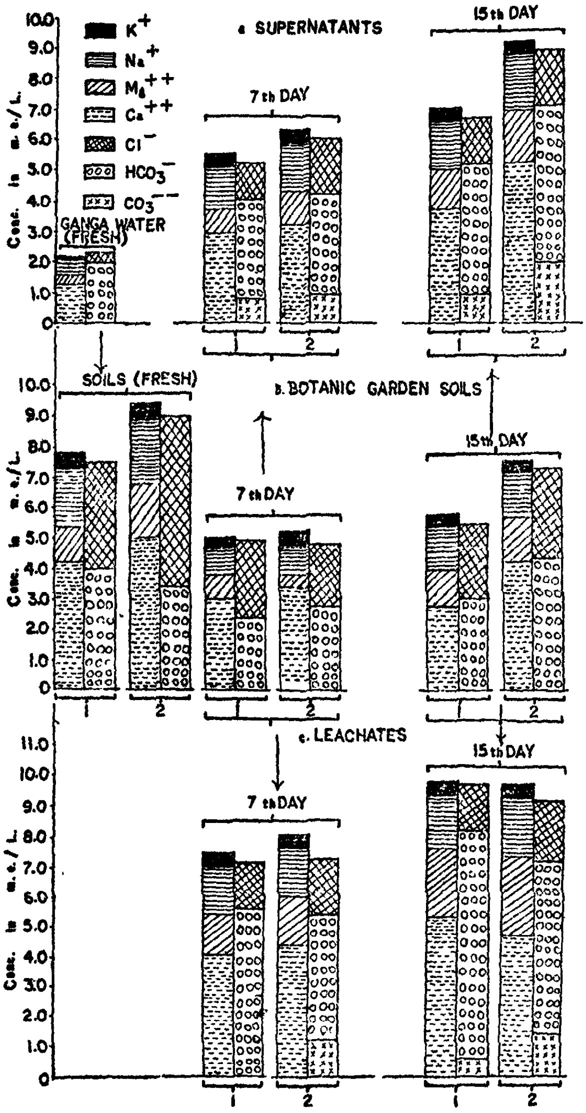

Fig. 3. Showing impact of Ganga water on the experimental Indian Botanic Garden Soils.

a. Mineral status of fresh ganga water and subsequent supernatants on 7th and 15th day of experimental flooding.

b. Mineral status of fresh Botanic Garden (BG) soils, and the same on 7th and 15th day of experimental flooding.

c. Mineral status in the leachates of respective experimental soils on 7th and 15th day of experimental flooding.
(Arrow indicate the direction of flow of liquids).

The soil pH recorded in table 2 makes it clear that the soils from both the ends of the garden are feebly acidic in reaction. The pH of the soils treated for 7-days of inundation are higher than the soils in original state. The soils treated for 15-days showed very insignificant increase in pH values over the 7-days treated soils.

CONCLUSION

It is deliberated that the eco-pedon system of the Indian Botanic Garden is very prone to inconspicuous consequences of riverine factors, such as, the inundation of the garden area due to occasional tidal overflow of Hooghly river water and subsequent waterlogging. As a result, the system is naturally plunged into a phenomenon of acute salt-imbalance. The experimental revealation of this soil-water interaction leads thus to the loss of half of the available vital mineral contents from the garden soil system within a week's submergence. However, on allowing further stagnation of the soil samples for a span of another week of waterlogging, that is, at the end of a 15-day period, the stock of soil minerals is found overwhelmingly depleted by getting lost to their immediate aqua-environment along with the phenomenal changes in the pH of the eco-pedon system. This initial influence of the river water on the eco-pedo-chemical status of the garden soil is explainable to the fact that the monsoonic tidal water of the river contains lesser concentration of dissolved minerals with pronounced sodium activity. Evidently, therefore, the mineral rich soil system is being eaten up in contact with the dilute river water and consequently strain the soil system to the salt imbalances in the process. Under the circumstances, the mineral revamping capacity of the present soil comes in aid of immediate restoration of delicate pedo-chemical balances with the release of a substantial amount of reserved soil minerals. However, the viability of the revamping process of the soil till it ceases, allows the habitat to withstand the veracity of nature and help protect the ground vegetation from immediate nutrient starvation with the uninterrupted supply of it from the natural mineral reserves of the soil. Therefore, the reckoning of immediate impact of inundation is not to appear till the vegetation, much affected ground flora, is free of standing water. The visual freshness in the vegetation so far languished under the impact of standing water ; and further, the sprouting of new ones in the affected habitat speak of the inconspicuousness of the milieu of the eco-pedo-chemical status of the ground system. The repeated nutrient replenishments by the potential revamping capacity of the soil under strains and stresses of flooding, as evident from the study, render the system imperceptibly impoverished of the valuable riches of soil. It is advisable, therefore, that necessary care be extended for the scientific management of the system usually after the flux of inundations or monsoon runoff of garden surface.

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