CHEMICAL CHARACTERISTICS OF NATURAL WATERS OF NILGIRI BIOSPHERE RESERVE, KERALA AND KARNATAKA - THEIR POSSIBLE UTILITY IN WILDLIFE MANAGEMENT

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Abstract: The present investigation deals with the chemical characteristics/composition of the natural waters of the Nilgiri Biosphere Reserve (NBR), located within Kerala and Karnataka States respectively. Waters of both localities differ significantly in their chemical characteristics and composition. The waters of NBR - Kerala are bereft of dissolved minerals in their per unit volume, irrespective of their sources and location. Calcium ions dominate within cations and bicarbonate within anions. Carbonate ions are conspicuously absent in all waters. In contrast to above, the waters of Karnataka have sufficient dissolved minerals in their per unit volume and magnesium ions are prominent within cations and chloride within anions in large number of water bodies. Carbonate ions are sufficiently present in majority of the waters. In both localities, the calcium and magnesium ions show a close resemblance in their concentration but sodium ions exhibit an erratic variation. The waters of NBR - Kerala are neutral to moderately alkaline in reaction (pH 7.0-8.4) but the Karnataka waters show comparatively high alkalinity (pH 7.0-9.0). The waters of NBR - Kerala have been categorized as C_1S_1 class and thus, found to be highly suitable for safe use either by the flora, fauna or even by the soils of the area but the waters of NBR - Karnataka, barring a few, have been categorized as C_2S_1 class and thus, suitable for fauna but may create problem of alkali hazards within soils and for plant species which are susceptible to sodium ions concentration. The present study pertinently suggests that to compensate the mineral deficiency especially in carnivores, the salt-licks having sufficient minerals may be placed in the entire biosphere reserve under Kerala and within Karnataka, it may be placed within those area which are not covered by artificial tanks.

INTRODUCTION

Out of three basic elements viz., Carbon, Hydrogen and Oxygen (CHO) which compose approximately 95% to 98% portion of a body of either a flora or a fauna, the water is the donor of two i.e. Hydrogen and Oxygen and thus, it establishes its most extraordinary position within the life supporting compounds vis-à-vis its most ordinary status in any ecosystem on the earth. Besides, it always carries some dissolved minerals which not only maintain the normal physiological activities of the biota but its role within the soil-system is also noteworthy. It is a vital and potent factor within ecological parameters and acts as a pivotal component in the maintenance and conservation of the bio-physico-chemical matrices of the environmental conditions of a biosphere reserve. Water being basic component of life and one of the guiding factors, it is, therefore, considered to be of paramount importance to study its chemical characteristics/composition. This study may prove of immense practical value in the conservation of the area.

The Nilgiri Biosphere Reserve (NBR), which encompasses the adjoining territories of Tamil Nadu, Kerala and Karnataka and is one of the richest centres of biological diversity in peninsular India, came into existence in September, 1986. Out of 4000 species of flowering plants in Western Ghats, there are about 3000 species in NBR, of which about 100 are rare and endangered occurring in an area of about 5520 km^2; of this *ca* 2537.6 km^2, 1455.4 km^2 and 1527.4 km^2 fall under Tamil Nadu, Kerala and Karnataka respectively. The water factor of Tamil Nadu portion of NBR has been described elsewhere (Singh, 2005b); under present investigation the water regimes of Kerala and Karnataka have been surveyed. The Kerala portion of NBR is located between at 11°05'to 11°10'N latitude and 76°21' to

76°28' E longitude and falls under monsoonic type of climate. It receives both South-West and North-East monsoons, however, maximum precipitation of over 5000 mm occurs during the South-West monsoon annually. The average minimum temperature ranges from 8°C to 14°C and maximum 23°C to 29°C. According to climate, the vegetation of the area is tropical evergreen forest. Karnataka counterpart is located at the coordinates of 11°36' to 12°15' N and 76° to 77°15' E and is characterized by three seasons *viz.*, dry, wet and cold. The maximum precipitation is received during early June to September from South-West monsoon. The average temperature varies from 18°C to 30°C in Bandipur and 12°C to 32°C in Nagarhole National Park. The vegetation of the area varies according to rainfall, from scrub in the South-East part where rainfall is lesser to dry deciduous and moist deciduous types towards the North-West.

Both the areas are rich in varieties of herbivores and carnivores. For both flora and fauna the sources of water are either rains, springs and streams which form the perennial drainage system of the biosphere reserve. While working on the subject the hydro-botanical/ecological works of Hooker (1907); Champion (1936); Bor (1938); Misra (1946); Sreenivasan (1964); Meher-Homji (1965 and 1967); Champion and Seth (1968); Ambasht (1971); Kaul (1977); Singh and Ghosh (1984, 1988); Nayar and Shastry (1987, 1988 and 1990); Singh and Shastry (1988); De (1992); Ambasht and Srivastawa (1994); Singh and Mudgal (1998); Srivastawa and Ambasht (1998); Ambasht *et al.* (1999); Rey Benyas *et al.* (1999); Gaston (2000); Woltemade (2000); Emery *et al.* (2001); Downing and Leibold (2002); Singh (2003, 2004); Pimm and Brown (2004); Giller *et al.* (2004); Nessa and Tasman (2005) and Singh (2005a,b) have been reviewed.

The site characteristics of NBR - Kerala may be described roughly as a rectangular table-land, closed on all sides. Due to presence of high ridges all around, the whole plateau is shielded from extremes of climate and has developed its own special micro-climate. NBR-Karnataka extends from East of Brahmgiri hills in the North and across the river Kaveri to include the Bandipur Tiger Reserve. Major portion of the terrain is gently undulating interspersed with hills varying in altitude from 1144 m to 1538 m. The average elevation is around 800 m.

MATERIALS AND METHODS

Within Kerala portion of NBR, the natural sources of water are streams, springs and rivers but in Karnataka counterpart, besides these above sources, the authorities have excavated some artificial tanks for Wildlife which are strictly rain fed reservoirs of a large dimension and there water remains stagnant. These tanks are common both in Bandipur and Nagarhole Sanctuaries. The water bodies of biosphere reserve enlisted in Table-1 have been sampled for surface level (0-15 cm). The water sampling was replicated thrice according to seasons *viz.*, November/ December 2003, April/May 2004 and July/August 2004. From each source one composite water sample has been prepared out of 20-30 samples collected along the length and breadth of the respective water body. Altogether, 42 water samples were collected from Kerala and 66 samples from Karnataka. Each water sample has been analyzed for various cations and anions *viz.*, calcium, magnesium, sodium and potassium (cations) and carbonate, bicarbonate, chloride and sulphate (anions). Electrical conductivity (E.C.) and pH were also determined. On the basis of these analyses its related properties such as Soluble Sodium Percentage (SSP), residual carbonate in m.e./l and Sodium Adsorption Ratio (SAR) were also computed. The sodium and potassium have been estimated by flame photometer, pH by potentiometric method and electrical conductivity by solu-bridge. For other analysis USDA, Hand Book No. 60 (Richard, 1954) has been used as the reference.

RESULTS AND DISCUSSION

The chemical composition/characteristics of the waters of NBR - Kearla and Karnataka are embodied in Tables -1 and 2 and Figs. 1-3(a & b) and $3(a_1)$ & $3(b_1)$. The water bodies may be categorized into five

Table-1: Location and sources of waters along with their chemical characteristics from NBR, Kerala

Sl. No.	Locality	Water body	E.C. in micromhos/cm at 25°C	SAR	Residual Carbonate (m.e./l)
1	Mukkali Reserve Forest	Stream	120	0.149	0.6
2	Mukkali Rest House	Kunthipuzha River	125	0.158	0.1
3	15 km away from Mukkali towards Sairandhri (Hydel Project)	Stream	90	0.365	0
4	20 km away from Mukkali towards Sairandhri (Hydel Project)	Stream	80	0.201	0.6
5	Sairandhri (Hydel Project)	Stream	110	0.365	0.1
6	5 km away from Sairandhri (Hydal Project) towards Viliyamullumala	River	120	0.201	0.3
7	Viliyamullumala	Stream	110	0.365	0
8	Cheriya walakkad	Stream	115	0.337	0
9	Karingathode	Stream	85	0.182	0.3
10	Walakkad	Stream	90	0.258	0.4
11	Koyippara	Stream	110	0.298	0.5
12	Vellathatum (a)	Spring	60	0.224	0.4
13	Vellathatum (b)	Stream	105	0.365	0.2
14	Sundaki	Stream	80	0.156	0.3

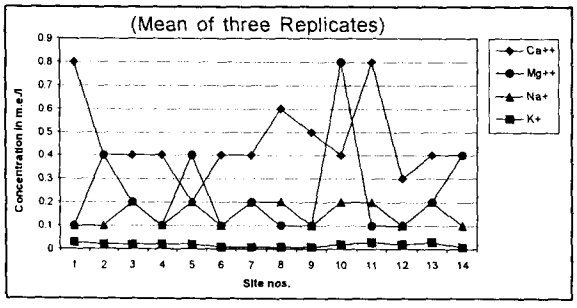

Fig. 1(a): Cationic variations of various water bodies of NBR, Kerala.

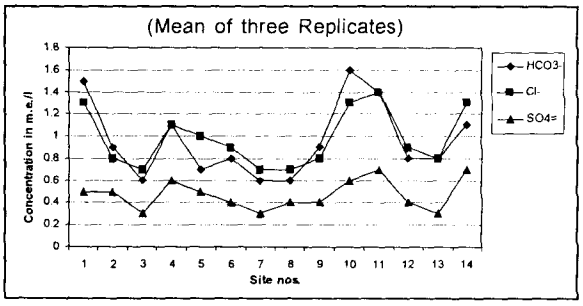

Fig. 2(a): Anionic variations of various water bodies of NBR, Kerala.

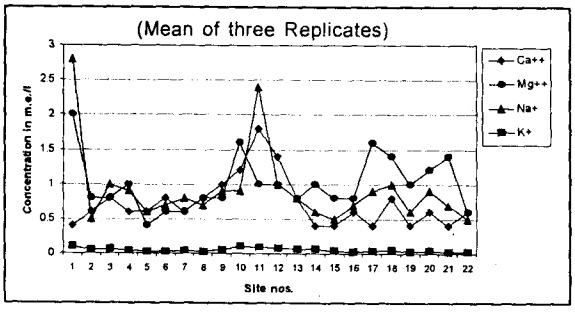

Fig. 1(b): Cationic variations of various water bodies of NBR, Karnataka.

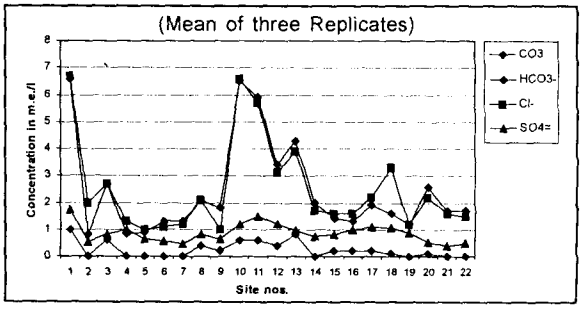

Fig. 2(b): Anionic variations of various water bodies of NBR, Karnataka.

Table - 2: Location and sources of waters along with their chemical characteristics from NBR, Karnataka

Sl. No.	Locality	Water body	E.C. in micromhos/ cm at 25°C	SAR	Residual Carbonate (m.e./l)
1	Budiparada	Well	480	2.557	5.3
2	Budiparada	Tank	210	0.598	0
3	K. Guri	Tank	260	1.118	1.7
4	Wonderfall Dam	Stream	180	1.006	0
5	K. Guri Hanagera	Tank	230	0.848	0
6	R.B.T. Range	Tank	205	0.830	0
7	Bailar	Spring	110	1.033	0.1
8	R.B.T. Range	Tank - II	215	0.782	0.9
9	Holsala Dam	Stream	260	0.949	0.2
10	Bandipur	Deep Well	510	0.760	4.3
11	Kekkanaahole	Tank	470	2.028	3.7
12	Bandipur	Tank -II	310	1.196	1.4
13	Moolehole	Well	475	0.894	3.5
14	Moolehole	River	160	0.717	0.6
15	Nagarhole	Pickok Tank	220	0.648	0.4
16	Nagarhole	Pickok Tank - II	215	0.837	0.1
17	Nagarhole	Thodalla Tank	210	0.904	0.1
18	Nagarhole	Kulchi Tank	215	0.953	0
19	Nagarhole	Nageswar Tank	220	0.718	0
20	Nagarhole	Stream	180	0.949	09
21	Nagarhole	Kayeetore Tank	220	0.738	0
22	Nagarhole	Marrappa Tank	260	0..645	0.5

types, *viz.*, stream, spring, river, well and tank. Results obtained for electrical conductivity (E.C.) observed at 25°C and pH clearly reveal that waters are not saline but alkaline in reaction irrespective of their sources and location. Observations on E.C. further exhibit that concentration of charge carrying particles within waterbodies is directly proportional to their respective depth of the free flowing water and their degree of stagnation. A deep well at Bandipur (Tiger Project area) exhibits the highest E.C., i.e., 510 micromhos/cm, followed by a similar well at Budiparada in Chamrajnagar Forest Division where E.C. has been recorded as 480 micromhos/cm. On the basis of E.C., the water bodies of the biosphere reserve may be arranged as well > tank > river > stream > spring. The values of E.C. within stream waters located in Kerala, range in between 80 micromhos/cm and 120 micromhos/cm at 25°C but their counterpart in Karnataka have variations in between 180 and 260 micromhos/cm at the same temperature. Such wide range of variation between two localities may be explained by the nature of the rock over which flow these waters as also by their flowing speed and their contact with soil systems. The other water bodies such as rivers and springs of both sites have E.C. variations in between 120 and 160 micromhos/cm and 60 and 110 micromhos/cm respectively. The waters of tank reservoirs, which are confined to NBR - Karnataka only, show variation in E.C between 205 and 470 micromhos/cm at 25°C. Such wide range of variation among artificial tanks may be due to their varied disposition, dimension and edaphic characteristics of *in-situ* soil system. Similar results have earlier been recorded by Singh

and Ghosh (1988), Singh and Shastry (1988) and Singh and Mudgal (1998) from chemical studies of natural waters of Indian Botanic Garden at Shibpur, Howrah, Similipal (Orissa) and Nokrek Biosphere Reserve (Meghalaya). It is further noticed that E.C. values are comparatively lesser during monsoon but higher during summer (May/June) because of increase and decrease of water volume of the water bodies.

Observations on pH presented in Figs. $3(a_1)$ and $3(b_1)$ reveal that waters of both sites are neutral, feebly to moderately alkaline in reaction but a few water samples confined to NBR - Karnataka show higher alkalinity (pH 9.0). The range of variation of pH within waters of Kerala is 7.0 to 8.4 but Karnataka, the variation is 7.0 to 9.0. However, the waters of artificial tanks are neutral to moderately alkaline (pH 7.0 - 8.9). During monsoon, the pH of water is relatively higher than in other two seasons. The pH of waters of these reservoirs is significant because the soils are slightly to moderately acidic. Under this situation, waters with alkaline reactions are not only favourable to the flora and fauna but to the soil system too.

The cationic variations of the water samples are presented in Figs.1(a) and 1(b). They exhibit that Ca^{++} and Mg^{++} ions have close resemblance but Na^{+} ions show erratic variation in its concentration. In case of K^{+} it maintains an insignificant variation within water samples of different water bodies. It is further noticed that Na^{+} ions are more pronounced during monsoon season in all the waters irrespective of their sources and location. The possible reason for such dominance of sodium concentration in waters during monsoon may be due to the presence of water-hull around sodium ion which reduces its degree of tenacity with the soil seat and consequently these ions get quickly removed to

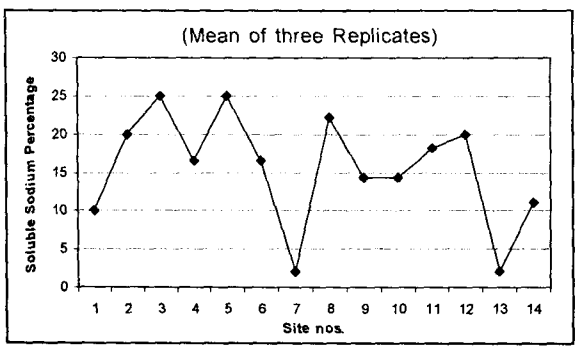

Fig. 3(a): Soluble Sodium percentage variations of various water bodies located in NBR, Kerala.

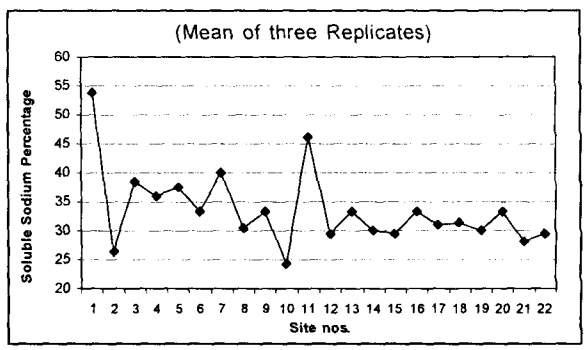

Fig. 3(b): Soluble Sodium percentage variations of various water bodies located in NBR, Karnataka.

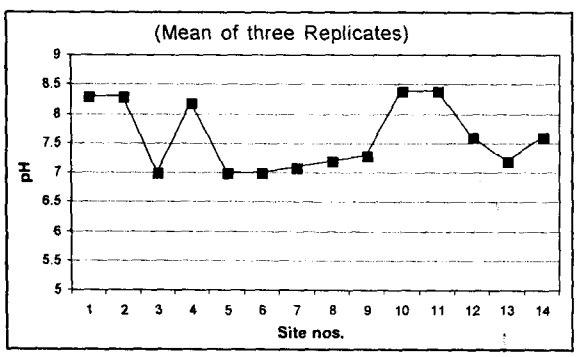

Fig. 3(a_1): pH variations of various water bodies located in NBR, Kerala.

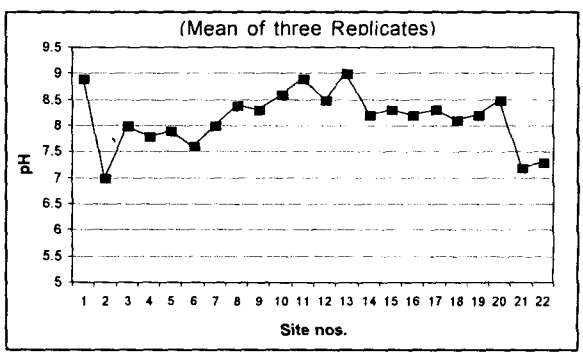

Fig. 3(b_1): pH variations of various water bodies located in NBR, Karnataka.

aqua media. In general, the calcium ions have been found to be the dominant charged particle within cations of majority water samples under NBR - Kerala but within NBR - Karnataka, the water samples show a different trend where about 77% samples of the locality show magnesium ions domination over calcium; the remaining 23% follow a trend similar to Kerala. The calcium and magnesium ions vary in the waters of NBR - Kerala from 0.2 to 0.8 m.e./l and from 0.1 to 0.8 m.e./l respectively but the same cations demonstrate their respective variations in between 0.4 to 1.8 m.e./l and 0.4 to 2.0 m.e./l in the waters of NBR - Karnataka. Similarly, the monovalent cations *viz.*, sodium and potassium vary in between 0.1 to 0.2 m.e./l and 0.01 to 0.03 m.e./l in the waters of Kerala, and, 0.5 to 2.8 m.e./l and 0.02 to 0.1 m.e./l in the waters of NBR - Karnataka respectively. As per their dominance these cations may be arranged as $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$ within NBR - Kerala and $Mg^{++} > Ca^{++} > Na^{+} > K^{+}$ within NBR - Karnataka.

The anionic variations in waters of these water bodies are presented in Figs. 2(a) and 2(b). Bicarbonate ions are prominent within anions with a wide range of variation from 0.6 to 1.6 m.e./l in the samples of NBR - Kerala. It is noteworthy that carbonate ions are conspicuously absent in all the water samples of the region irrespective of their sources and location. As against this, more than half water samples from NBR - Karnataka exhibit the presence of carbonate ions with remarkable variation of 0.1 to 1.0 m.e./l. Besides, chloride and bicarbonate ions show a close resemblance with insignificant domination of chloride ions over bicarbonate. The anions may be arranged as per their dominance as $HCO_3^{-} > Cl^{-} > SO_4^{=} > CO_3^{=}$ within waters of NBR - Kerala and $Cl^{-} > HCO_3^{-} > SO_4^{=} > CO_3^{=}$ within NBR - Karnataka. It is further observed that like sodium, the chloride ions, too have been found to be highly pronounced particularly during monsoon.

Observations made on other relevant properties of the waters *viz.* Sodium Adsorption Ratio (SAR) and Soluble Sodium Percentage (SSP) reveal clearly that these two parameters are present in the waters of the biosphere reserve under safe level. On the basis of E.C. and SAR values, which are used in determination of water quality (Rechard, 1954), the entire waters of NBR - Kerala irrespective of their sources and location may be placed under C_1S_1 category i.e. low E.C. and low SAR. Such waters are highly suitable and safe for the flora, fauna and any type of soil of the area. Their values range in between 0.149 and 0.365 for SAR and 10.0% and 25.0% for SSP. For NBR – Karnataka, approximately $2/3^{rd}$ of the water samples follow a trend similar to Kerala but $1/3^{rd}$ water samples fall under C_2S_1 class i.e. moderate E.C. and low SAR. Such waters are safe for the use of fauna of the area but for flora, their qualities may raise an alarm against salt susceptibility, and for soils, it may induce sodium hazards. The range of SAR in the waters of NBR - Karnataka is 0.645 and 2.557 for SAR and of SSP 24.3% and 53.8%. It is further observed that residual sodium carbonate is present in all the waters except three samples from NBR - Kerala but its presence is within safe limit. It is noted with concern that all wells and one tank located within Karnataka portion of NBR, have crossed the danger mark level for residual sodium carbonate concentration (Richard, 1954). However, these waters are quite safe for the use of fauna but may create sodium hazards within soil system, and also are not safe for flora except for the sodium tolerant species. The waters of other major tanks located within the Nagarhole Wildlife Sanctuary are quite safe and suitable for the flora, fauna and soils and qualitatively superior over other water sources of the biosphere reserve.

The present study clearly suggests that the water regimes of the two localities *viz.*, Kerala and Karnataka are quite distinct in their chemical composition and characteristics. The waters of NBR - Kerala are chemically dilute and bereft of dissolved minerals irrespective of their sources and location. Such quality of water may not affect the flora of the area because their soils are quite rich in minerals, but the fauna probably suffer from mineral deficiency of the free water resources. The mineral riches of the forage grasses may be compensating the mineral deficiency caused due to waters in the herbivores. To compensate such mineral deficiency especially in

carnivores, it is proposed, that salt-licks having sufficient minerals may be placed in the entire biosphere reserve under Kerala. Contrary to NBR - Kerala, the Karnataka counterpart has some artificial tanks for Wildlife. These tank waters are qualitatively superior over waters of other natural sources. Baring one tank, whose alkali hazards may create problems for soils and flora, the fauna of the area gets benefited.

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