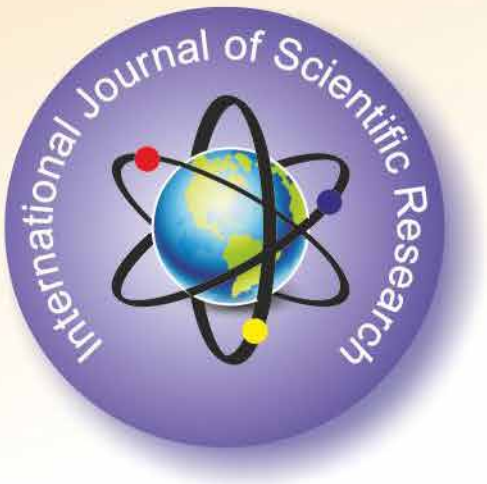
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Research Paper

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Ionic composition of a freshwater lake and its implications on aquaculture

Biotechnology

KEYWORDS : Cat ions, Anions, Soda Lakes, Saline, Sodium sulphate

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ABSTRACT

Ionic composition of lake water helps in determining the suitability for aquaculture. Dissolved gases are often used for the same, but the concentration of cat ions and anions alone can discard the site for use unless it is properly reclaimed. Chemical factors determine the lethal and sub-lethal effects on organisms. An attempt to understand the relationship between the basic ions in Hadhinaru Lake of Mysore has been done. Sodium ions are dominant while calcium and magnesium fluctuate to a grater extent and potassium ions are least. Among the anions sulphates dominate and carbonates are least. The lake water does not follow the general rule suggested by Rhode (1949) for fresh waters and is tending to become saline. According to Hutchinson's classification the lake is similar to soda lakes of Africa. Residual Sodium Carbonate and sodium content are high but the Sodium Absorption Ratio which is high can be used in the reclamation of the water. The lake water is not suitable for aquaculture.

Introduction

Chemical characteristics of lake waters are most important in determining the suitability of the site for aquaculture. Ionic composition of tropical freshwaters have been dealt with by Khan and Quayyum(1966), Rao(1955) Rao(1971), Bharathi and Hosmani(1977), while Birge and Juday(1911), Pearsall(1921), Clarke(1924), Maucha(1932) Rhode(1949) and Wellcome(1972) have studied temperate waters .Ryeder et al(1974) have made an elaborate study on the morphoedaphic index as a fish yield indicator in fresh waters. The selection of a lake for a particular use is mainly based on the presence of related chemicals in it. The classification of lake water for culture is usually according to the salt content (salinity) of the medium. The major types distinguished are freshwater, brackish water, marine on a higher scale and hard and soft waters on a lower scale (Hutchinson 1957). The suitability of the water will be decided on the specific organisms to be cultured and the specific culture system to be used. Although many aspects of water including dissolved gases such as oxygen, carbon dioxide and ammonia, concentrations of various other ions (pH, dissolved oxygen, conductivity) are accounted; the chemical factors alone can discard a lake for use unless it is properly reclaimed. Chemical factors are important because of their lethal and sub-lethal effects on cultivable organisms in water. This in turn has an impact on the biological productivity through the food chain.It is of relevance that information on water quality parameters are not just meant for site selection, but also for management of the culture systems such as fish culture.

The present work is an attempt to understand the relationship of the basic elements in a large lake, Hadhinaru Lake in Mysore, Karnataka.

Materials and Methods

Hadhinaru Lake is located at 1202' north latitude and 7604' east longitude at an altitude of 753 meters above MSL and is situated 16 kms away from Mysore city (Karnataka). It has an independent catchment area of 9.57sq.km with water spread over 10.10 hectares having a live capacity of 54.43 mcft. The maximum depth of the lake when full is five meters. It is important from the Social-Economic-Natural-Cultural-Lake-Ecosystem (SENCLE) of the area Hosmani(2012).

Basic elements such as Sodium(Na+), Potassium(K+), Calcium(Ca2+) Magnesium(Mg2+), Sulphates(SO42-), Carbonates(CO3-) and Chlorides(Cl-) were analysed as per the methods described in APHA(1995) for a period of one year(July 2009 to June 2010). The values were expressed as mg/L and were later converted to meqs/L wherever necessary.

Results and discussion

The basic ionic composition of the lake water is presented in Table 1 and the ionic hierarchy is presented in Table 2. The ionic diagrams indicating the dominant ions are presented in Fig.1. Rodhe(1949) suggested a general rule for all fresh waters as Ca+>Mg+>Na+>K+ and CO3->SO4-->Cl- for all fresh waters, while the ionic pattern for marine water as Na+>Mg+>Ca+>K+ and Cl->SO4->CO3-. Khan and Quayyum(1966) observed that many tropical fish ponds of Aligarh obeyed Rodhe's(1949) rule. Clarke(1954) also found that soft waters that were fresh had Sodium chloride in abundance and further typical soft waters that were considered fresh had low levels of Calcium and carbonate as compared to Sodium and chloride .Bharathi and Hosmani(1977) studying sixteen lakes of the districts of Hassan and Chitradurda of Karnataka found that they tended to follow the pattern suggested for soft water. Hutchinson(1957) defines salinity of water as the concentration of all cat ions, significantly sodium, potassium, calcium, magnesium and the anions , sulphates, chlorides and all bicarbonates being converted to carbonates. Calcium and carbonates may be much reduced in soft waters, while sulphate may be dominant in acid waters. Dominant ions can characterize natural waters as:

a. Sodium and chloride in sea water, Calcium and bicarbonate in calcareous water (Calcium Bicarbonate).

B . Sulphate and bicarbonate in Sulfalo-carbonate water

c. Sodium, Magnesium and bicarbonate water (Soda lakes found in Africa)

All the three types can be seen in Hutchinson (1957) classification which were represented by ionic diagrams

Among the anions sulphates dominate for a major period of the year. Chloride ions are equally distributed alternating with carbonates with lesser dominance. These observations suggest that the lake water does not follow the general rule for fresh waters. However the dominance of Sodium chloride indicates that the lake water is tending to become saline. This may be attributed to the uncontrolled anthropogenic activities around the lake. The lake fits into the fourth category suggested by Hutchinson(1957)-Sodium-Magnesium-bicarbonate similar to soda lakes of Africa. The electrical conductivity of the lake is always higher than 560 µ mohs reaching a maximum of 1002 µ mohs during the month of July(Fig 2). This is because of the very high nutrients brought into the lake during rains. Many of the workers like Khan and Quayyum(1966) and Rao(1971) have observed that polluted waters do not tend to follow the general rule. Thresh et al.(1944) pointed out that abundance of chlorides is due to animal origin. Although not very prominent, chlorides must have been associated with other materials due to human activities.

Since Ions combine in terms of their equivalent weight some secondary calculations were made to find the suitability of the lake water for other purposes. Sodium was the dominant ion. Its significance can be known by calculating the Residual Sodium Carbonate (RSC), Sodium Absorption Ratio (SAR) and the Percent Sodium in the lake water. The Alkalinity as CaCO3, Total hardness as CaCO3, and Calcium, Magnesium, sodium and potassium values of mg/L were transformed to meqs/L and substituted in the formulae below and the results are presented in Table 1.

a. RSC=Alkalinity-total hardness; b. SAR=Na/√Ca + Mg/2; c. % Sodium=Na x 100/Na + K +Ca + Mg

Sodium hazard and salinity (Wilcox and Hatcher, 1955) are also used to classify lake waters. The SAR represents sodium hazard ratio. This ratio directly indicates the absorption of sodium by the soil in the basin of the lake (Table 3)

Table 3: Classification of water class using SAR and RSC

Classification of Todd(1959)		Classification of Richards(1954)	
SAR	Water class	RSC(epm)	Water class
<10	Excellent	>2.5	Unsuitable
10 to 18	Good	1.25 to 2.5	Marginally suitable
18 to 26	Fair	<1.25	Safe
>26	Poor		

The values of RSC for the lake indicate that the water class is quite unsuitable for aquaculture). During the months of December and March it reaches very high levels. On the contrary SAR values indicate that the water quality is excellent. The output of these observations is that the sodium absorption ration of the soil is high but the residual sodium carbonate is low. Further the percentage of sodium in the water ranges between a minimum of 22 to a maximum of 47.

Conclusion

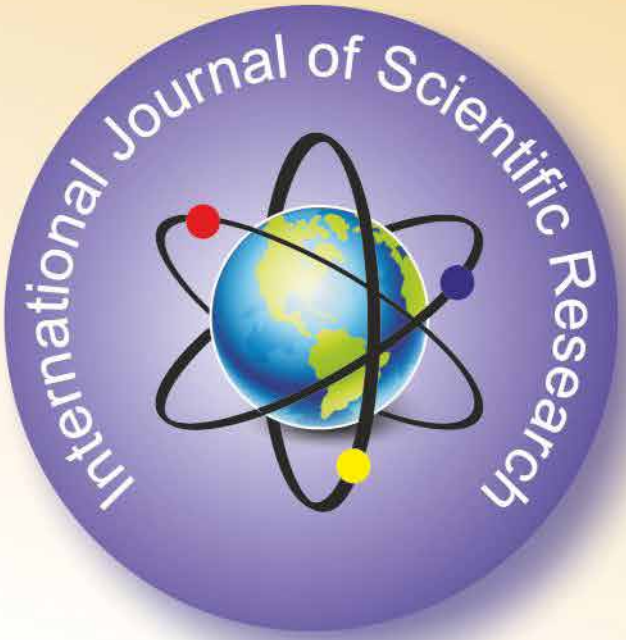
Considering the suitability of Hadhinaru lake water for aquaculture based on the ionic composition; the following observations can be derived. Sodium ions are the dominant ions for a major part of the year. Calcium and magnesium ions fluctuate between the second and the third positions among the cat ion composition. Among the anions sulphates dominate while carbonates are the least. The lake water does not fit into the general rule suggested by Rodhe1949). The persistence of sodium chloride to a certain extent indicates that the water is tending to become saline. According to the pattern suggested by Hutchinson(1957) the lake can be categorized as Sodium-Magnesium-Carbonate similar to soda lakes of Africa. The residual sodium carbonate is rarely below the prescribed levels for fresh water lakes and suggests its unsuitability for aquaculture. The sodium absorption ratio is high and this factor can be made use to reduce the sodium content in the water which has reached levels of 47% at certain time of the year. The study of ionic composition of lake water helps in understanding the suitability of fresh waters for their economic utility.

Table 1. Monthly fluctuation in the ionic composition of Hadhinaru lake(2010)

	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	Apr	May	June
Sodium(mg/L)	80	39	35	40	38	42	52	31	54	60	50	52
Potassium(mg/L)	15	4	2	3	2	2	2	2	6	8	6	3
Calcium (mg/L)	12	33	26	32	38	35	32	14	31	16	64	28
Magnesium(mg/L)	35	20	18	33	9	16	18	37	66	32	17	46
Carbonates(mg/L)	117	100	70	40	20	450	70	70	180	80	120	100
Sulphates(mg/L)	240	80	22	100	480	430	400	300	0	320	240	230
Chlorides(mg/L)	103	82	114	85	55	58	61	21	31	93	65	53
E.C µ mohs	1002	640	600	560	590	580	590	680	690	830	740	700
RSC(epm)	1.4	1.5	0.9	1.8	1.8	4.0	2.8	2.0	5.3	0.9	2.6	1.0
SAR(Ratio)	2.6	1.3	1.3	1.6	1.5	1.4	1.8	1.0	1.2	1.9	1.4	1.4
Sodium(%)	47	33	35	42	33	36	44	22	27	41	31	30
Alkalinity(epm)	3.4	3.3	3.6	4.3	3.0	4.2	4.8	3.7	6.9	3.5	4.6	5.2
T.Hardness(epm)	2.0	1.8	2.7	2.5	1.2	0.2	2.0	1.7	1.7	2.6	2.0	4.2

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