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A perspective on the Silicate silicon estimation of a wetland ecosystem

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Abstract
Estuarine and wetland habitats have a naturally high level of productivity that in some cases, enhanced by anthropogenic supply of nutrients carried by rivers. Excessive nutrients leads to harmful or noxious algal blooms, shifts in food chains, increased sedimentation of organic particles and ultimately depletion of dissolved oxygen particularly in bottom waters. Ashtamudi lake as a backwater resource is one of the richest source of fishery resources. In the present investigation a knowledge on the silicate content of the upper and lower zones of the Chavara south region of Ashtamudi lake was undertaken. The silicate of surface water ranged from 0 to 5600 µg SiO4.Si/l and the bottom water from 0 to 7700 µg SiO4.Si/l in 2008- 2009. The silicate of surface water ranged from 0 to 6300 µgSiO4.Si/l and the silicate of bottom water from 0 to 5600 µgSiO4.Si/l in 2009-2010.High silicate content may be due to heavy discharge of sewages and fresh water delivered from land drainage carrying silicate leach out from rocks. The increased supply of silicate silicon may be due to the exchange of silicon resulting from a direct reaction between the sediment and the overlying weathering of suspended materials. In this context the nutrient enrichment related adverse effects have to be addressed. All these point to the necessity of formulating suitable conservatory measures ensuring proper operation and maintenance of water quality standards. Sustainable management of this resource has become vital for prevention of over exploitation.

Keywords: silicate silicon, eutrophication, ecotourism, humic compounds

Introduction

Ecotourism is a purposeful travel to natural areas to understand the cultural and natural history of the environment, taking care not to alter the integrity of the ecosystem while producing economic opportunities that make conservation of natural resources beneficial to local people. Kerala, of all the states in India offers the maximum potential for the promotion of ecotourism. Kollam, one of the leading centres of the ancient world is also the starting point of the backwater ways encompasses the Ashtamudi lake known as the gateway to the backwaters. To ensure that the water quality is being maintained or restored at desired level it is important that it is monitored on a regular basis.

Nutrients in the aquatic environment refers to the dissolved inorganic forms of nitrogen, phosphorous and silicon that is utilized by photosynthetic organisms in the form of organic matter. The nutrients supply from fresh water inputs is important in sustaining their high rate of primary production, but today estuaries receive some of the highest input of nutrients because of the local influence from land drainage and pollution from urbanization in the banks of estuaries that in turn reduces the water quality creating eutrophication. The source of silica to the marine environment is mainly through river discharges. Silicon is biologically essential for the growth and the formation of their skeletal materials in marine organisms like diatoms, radiolarians and sponges. The availability of silicate silicon is one of the important factors that can regulate the species composition of phytoplankton assembly (Egge and Aksnes, 1992) [1]. Unusually high values of dissolved silicates stimulate growth of diatoms, one of the most common groups of phytoplankton.

The physical processes in large lakes are complicated due to the flow regime, effluent discharge from urban run off and untreated pollutant wastes. In the present study hence a long term investigation of the silicate content in the upper and lower strata of the Chavara South region of Ashtamudi lake was done. The study will quantify the nutrients to study its pathway and dispersal that helps to monitor the effects of pollution in the lake. Maintaining the hydrological regime of a wetland and its natural variability is necessary to maintain the ecological characteristics of the wetland including its biodiversity.

2. Materials and Methods

Monthly collection of water samples for hydrographical studies have been made from four selected sites of Chavara south region of Ashtamudi estuary in Kollam district for a period of two years (From June 2008 to May 2010), covering three prominent seasons of the year (pre-monsoon, monsoon and post-monsoon). All collections were made invariably between 6 am and 8 am. Surface and bottom water samples were taken in good quality polyethylene containers for the analysis of certain physico-chemical factors. Maximum care was taken in taking samples, their preservatives, storage and analysis. The samples were brought to the laboratory immediately after collection, for analyzing its various physico-chemical characteristics using standard methods. Silicate silicon is determination based on the formation of a yellow silicomolybdate when an acid sample is titrated with molybdate solution using ascorbic acid as reductant, spectro photo metrically at 810 nm (Grassh off *et al.*, 1983) [3]. The data collected at monthly intervals from all the stations were statistically analysed, with a view to understand the nature of variations in the physico-chemical parameters between stations and seasons. Analysis includes Mean, Standard Deviation, Anova.

3. Result

In Station 1, the silicate of surface water ranged from 0 to 5600 µg SiO4.Si/l in 2008-2009 and from 0 to 3150 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 1412.5 ± 720.64, 1750 ± 1285.98, 1041.25 ± 626.16 respectively in the first year and 1487.5 ± 774, 1225 ± 677.77, 1137.5 ± 628.95 respectively in the second year. The annual mean ± SE was 1401.25 ± 490.72 in 2008-2009 and 1283.33 ± 366.41 in 2009-2010 (Table 1 and Fig 1 a & 2 b).

Station 1, the silicate of bottom water ranged from 350 to 3700 µg
SiO4.Si/l in 2008-2009 and from 42 to 3500 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 2150 ± 850.25, 1225 ± 364.24, 1062.5 ± 584.3 respectively in the first year and 1323 ± 781.72, 612.5 ± 167.55, 1400 ± 515.19 respectively in the second year. The annual mean ± SE was 1479.16 ± 360.11 in 2008-2009 and 1111.83 ± 306.03 in 2009-2010(Table 1 and Fig 3a & 4 b).

In Station 2, the silicate of surface water ranged from 350 to 3500 µg
SiO4.Si/l in 2008-2009 and from 350 to 4500 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 962.5 ± 388.04, 1312.5 ± 502.65, and 2187.5 ± 578.21 respectively in the first year and 1050 ± 494.97, 1137.5 ± 220.2, 2100 ± 1020.42 respectively in the second year. The annual mean ± SE was 1487.5 ± 301.96 in 2008-2009 and 429.17 ± 376.71 in 2009-2010(Table 1 and Fig 1 a & 2 b).

In Station 2, the silicate of bottom water ranged from 350 to 5600 µg
SiO4.Si/l in 2008-2009 and from 350 to 3800 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 1662.5 ± 761.13, 2012.5 ± 747.6, and 3062.5 ± 1004.03 respectively in the first year and 1925 ± 580.41, 1575 ± 175, 2175 ± 976.49 respectively in the second year. The annual mean ± SE was 2245.83 ± 476.75 in 2008-2009 and 1891.67 ± 354.4 in 2009-2010 (Table 1 and Fig 3a & 4b).

In Station 3, the silicate of surface water ranged from 0 to 4500 µg SiO4.Si/l in 2008-2009 and from 0 to 6200 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 700 ± 247.49, 1325 ± 425, and 2187.5 ± 885.15 respectively in the first year and 1575 ± 827.02, 2187 ± 481.91, 3037.5 ± 1315.51 respectively in the second year. The annual mean ± SE was 1404.17 ± 356.41 in 2008-2009 and 2266.67 ± 522.79 in 2009-2010(Table 1 and Fig 1 a & 2 b).

In Station 3, the silicate of bottom water ranged from 0 to 3850 µgSiO4.Si/l in 2008-2009 and from 0 to 4200 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 2012.5 ± 719.77, 1750 ± 714.43, and 1137.5 ± 502.65 respectively in the first year and 2100 ± 820.82, 2362.5 ± 675.89, 1987.5 ± 681.41 respectively in the second year. The annual mean ± SE was 1633.33 ± 358.73 in 2008-2009 and 2150 ± 383.71 in 2009-2010(Table 1 and Fig 3a & 4b).

In Station 4, the silicate of surface water ranged from 0 to 4900 µg SiO4.Si/l in 2008-2009 and from 350 to 6300 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 612.5 ± 298.87, 1662.5± 719.77, and 2712.5 ± 1091.71 respectively in the first year and 1575 ± 707.25, 1750 ± 378.04, 2887.5 ± 1365.86 respectively in the second year. The annual mean ± SE was 1662.5 ± 479.98 in 2008-2009 and 2070.83 ± 508.79 in 2009-2010 (Table 1 and Fig 3a & 4 b).

In Station 4, the silicate of bottom water ranged from 350 to 7700 µg SiO4.Si/l in 2008-2009 and from 350 to 5600 µg SiO4.Si/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 2100 ± 1293.9, 1225 ± 364.29, 3937.5 ± 1976.67 respectively in the first year and 2012.5 ± 1215.59, 1575 ± 303.11, 1487.5 ± 690.83 respectively in the second year. The annual mean ± SE was 2420.83 ± 797.26 in 2008-2009 and 1691.67 ± 436.88 in 2009-2010 (Table 1 and Fig 2a & 3 b).

ANOVA comparing silicate of surface water between the stations,
2008-2009 showed variations between seasons significant at 5% level and for periods within seasons significant at 1% level. ANOVA comparing the silicate of surface water between the two years of study, Station 1 showed variation for the periods within seasons significant at 1% level. Station 2 showed variations for periods within season significant at 5% level. Station 4 showed variation between seasons significant at 5% level while station 3 showed no significant variations (Table 2 & 3).

ANOVA comparing silicate of bottom water values between the stations showed variations for periods within seasons significant at 1% level for the two years of study. ANOVA comparing silicate of bottom water between the years of study for station 2 and 4 showed variations between years, station 2 significant at 1% level and station 4 significant at 5% level (Table 4 & 5).

Table 1: Silicate (µg SiO4.Si/l) of water (2008-2010)

Year	Season	Month	Silicate (µg SiO_4.Si/l)							
			Station 1		Station 2		Station 3		Station 4	
			Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
2008-2009	Monsoon	JUN	2500	3700	700	3150	700	3850	0	5950
		JUL	0	1050	350	350	1400	1750	700	1050
		AUG	2800	3500	2100	2800	350	2100	1400	1050
		SEP	350	350	700	350	350	350	350	350

	Post-Monsoon	OCT	5600	1400	2800	4200	2500	3850	3500	2100
		NOV	350	2100	700	1050	700	1050	700	350
		DEC	700	350	1050	1750	700	700	350	1050
		JAN	350	1050	700	1050	1400	1400	2100	1400
	Pre-Monsoon	FEB	1050	700	3500	5600	1750	2450	1400	700
		MAR	0	350	700	700	0	0	350	350
		APR	315	400	2450	3150	4200	1050	4900	7700
		MAY	2800	2800	2100	2800	2800	1050	4200	7000
2009-2010	Monsoon	JUN	3150	42	350	2800	3850	4200	3500	5600
		JUL	0	1400	350	350	1750	1400	350	700
		AUG	2450	3500	2450	2800	350	2450	1750	1400
		SEP	350	350	1050	1750	350	350	700	350
	Post-Monsoon	OCT	3150	700	1750	2100	2800	4200	2100	1400
		NOV	0	350	1050	1400	3150	2450	2450	2450
		DEC	1050	350	700	1400	1050	1050	700	1050
		JAN	700	1050	1050	1400	1750	1750	1750	1400
	Pre-Monsoon	FEB	1400	700	350	1050	2100	2400	1050	350
		MAR	0	350	350	0	0	0	350	350
		APR	350	2100	4200	3850	6200	3100	6300	3150
		MAY	2800	2450	3500	3800	3850	2450	3850	2100

Table 2: ANOVA testing Silicate of surface water between the stations and seasons (2008-2010)

	2008-2009			**2009-2010**		
Source	Sum of squares	Mean Sum of squares	F Ratio	Sum of squares	Mean Sum of squares	F Ratio
Total	91540740.00			114977400.00		
Between stations	540024.00	180008.00	0.20	8279584.00	2759861.00	2.40
Between seasons	9875776.00	4937888.00	4.78*	6881552.00	3440776.00	2.96
Periods within seasons	47019078.00	5224342.00	5.05**	61512192.00	6834688.00	5.89**
Error	34105860.00	1033510.90		38304110.00	1160730.60	

Table 3: Anova testing Silicate of surface water between the years of study in stations

	Station 1			**Station 2**		
Source	**Sum of squares**	**Mean Sum of squares**	**F**	**Sum of squares**	**Mean Sum of squares**	**F**
Total	49592280.00			19398010.00		
Between years	83424.00	83424.00	0.30	3626.00	3626.00	0.00
Between seasons	773224.00	386612.00	1.24	86050.00	43025.00	0.08
Periods within seasons	45299709.00	5033301.00	16.11**	13614183.00	1512687.00	2.92*
Error	3435928.00	312357.10		5694154.00	517650.40	
		Station 3			Station 4	
Source	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	3742258.00			139606600.00		
Between years	498903.50	498903.50	2.50	122550.00	122550.00	0.00
Between seasons	28374.00	14187.00	0.07	27709060.00	13854530.00	5.17*
Periods within seasons	1056868.00	117429.70	0.60	82298340.00	9144260.00	3.41
Error	2158113.00	196192.10		29476680.00	2679698.20	

* denote significance ($p <. 05$)
** denote significance ($p <. 01$)

Table 4: ANOVA testing Silicate of bottom water between the stations and seasons (2008-2010)

	2008-2009				**2009-2010**			
Source	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**
Total	47	155581100.00			47	80587790.00		
Between stations	3	7572656.00	2524219.00	1.10	3	7016816.00	2338939.00	2.50
Between seasons	2	4494480.00	2247240.00	0.96	2	826160.00	413080.00	0.44
Periods within seasons	9	65943603.00	7327067.00	3.12**	9	40877442.00	4641938.00	4.95**
Error	33	46480020.00	1408485.00		33	30967380.00	938405.45	

Table 5: ANOVA testing Silicate of bottom water between the years of study in stations

	Station 1				Station 2			
Source	**DF**	**Sum of squares**	**Mean Sum of squares**	**F**	**DF**	**Sum of squares**	**Mean Sum of squares**	**F**
Total	23	30289580.00			23	7849818.00		
Between years	1	809600.00	809600.00	1.00	1	1514672.00	1514672.00	5.8*
Between seasons	2	2724396.00	1362198.00	1.62	2	109631.00	54815.50	0.21
Periods within seasons	9	17530947.00	1947883.00	2.32	9	3358673.00	373185.00	1.43
Error	11	9224632.00	838602.90		11	2866842.00	260622.00	
	Station 3				Station 4			
Source	DF	Sum of squares	Mean Sum of squares	F	DF	Sum of squares	Mean Sum of squares	F
Total	23	2765717.00			23	6735388.00		
Between years	1	565230.00	565230.00	4.60	1	1655452.00	1655452.00	7.9*
Between seasons	2	40773.80	20386.90	0.17	2	1100158.00	550079.00	2.61
Periods within seasons	9	814272.80	90474.75	0.74	9	1663829.00	184869.00	0.88
Error	11	1345441.00	122312.80		11	2315949.00	210540.82	

* denote significance ($p < .05$)

** denote significance ($p < .01$)

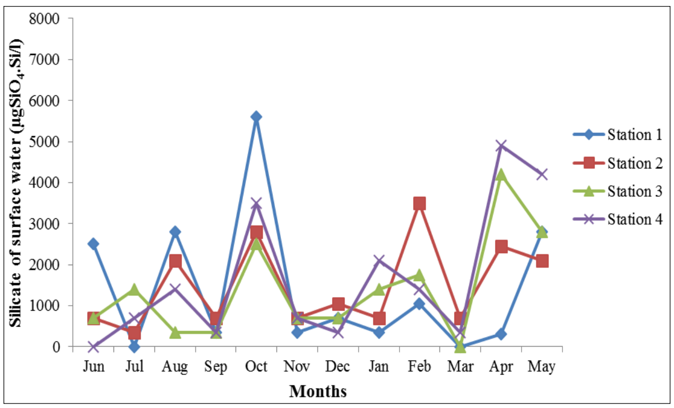

Fig 1: A Monthly variations of silicate of surface water (2008-2009)

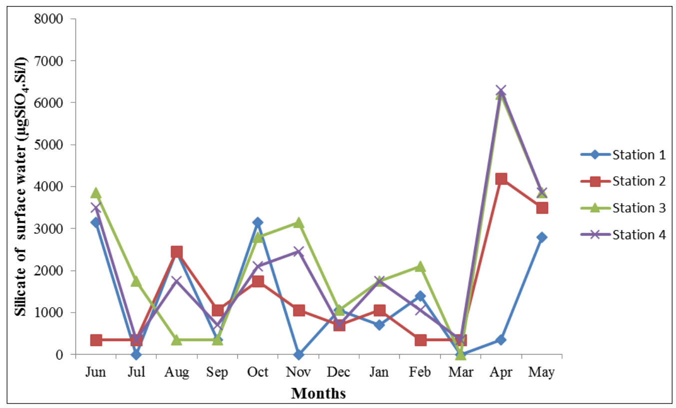

Fig 2: B Monthly variations of silicate of surface water (2009-2010)

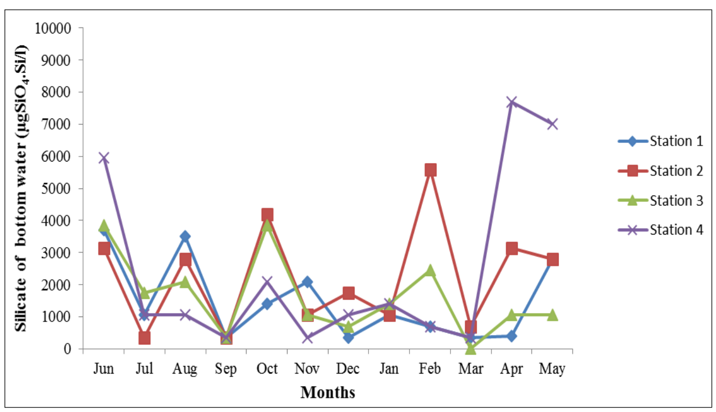

Fig 3: A Monthly variations of silicate of bottom water (2008-2009)

4. Discussion

Silica is an important nutrient to certain organisms such as diatoms and radiolarians. The dissolved silica is removed by such organisms to build their skeleton. The uptake of silicon by growing phytoplankton results in the depletion of silicon in sea water. When these organisms die and disintegrate silicon is rapidly liberated back to the aquatic environment. In the present study, the silicate of surface water ranged from 0 to 5600 µg SiO4.Si/l and the bottom water from 0 to 7700 µg SiO4.Si/l in 2008- 2009. The silicate of surface water ranged from 0 to 6300 µgSiO4.Si/l and the silicate of bottom water from 0 to 5600 µgSiO4.Si/l in 2009-2010. High silicate content may be due to heavy discharge of sewages and fresh water delivered from land drainage carrying silicate leach out from rocks. Further due to the turbulent nature of water the silicate from the bottom sediment might have been exchanged with overlying water in the estuarine environment. This conforms to the findings of Govindasamy *et al.*, (2000) [2]; Rajasegar (2003) [6]. Besides this the distribution of particulate silicon carried by the river, the removal of silicates by adsorption and co-precipitation of soluble silicate silicon with humic compounds and iron. The observed low silicate values could be attributed to uptake of silicon by phytoplankton for their biological activity. Similar instances were also reported by Mishra *et al.*, (1993) [4]. The silicate minimum values could be due to the weak fresh water flow and the removal by biological process. While there was an abrupt increase during the month of May can be explained on the basis of unusual behavior of silicate reported from Kerala back waters (Nair *et al.*, 1984) [5] and could be mainly attributed to the sewage discharge coincided with total occlusion of the estuarine mouth. The increased supply of silicate silicon may be due to the exchange of silicon resulting from a direct reaction between the sediment and the overlying weathering of suspended materials. Diatoms remove large amounts of silicon from seawater and the deficiency of this element seems to act as limiting factor in some areas.

5. Conclusion

The present study evaluated the incidence of a high quantity of Silicate silicon in the lower reaches of the Ashtamudi lake. This type of change detection study would enable in identifying the status and condition of silicate silicon in this wetland. Managing and protecting this god's own gift is essential for sustaining life. A continuous water quality monitoring program and proper water safety plan are essential for the preservation and improvement of the water quality. Urgent measures are to be taken to reinstate the natural environment of so as to conserve the native species of this lake.

6. Acknowledgement

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