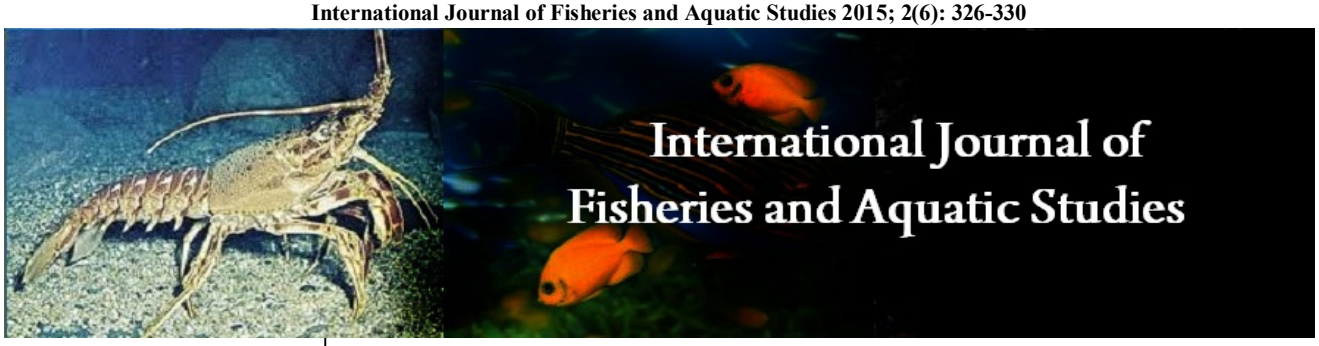

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Salinity fluctuations of upstream and downstream waters of Ashtamudi estuary

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Abstract

Estuaries are subjected to dramatic short and long term variations. The public must be educated on the ecological value of these resources. Ashtamudi estuary has been designated as a Ramsar site. So in the present study it is proposed to investigate fluctuations in salinity of four selected stations of Thekkumbhagam Creek of Ashtamudi estuary. The study revealed wide fluctuations in salinity that will in turn affect the dissolved oxygen concentration of the estuary. Further these studies will go long way in helping the authorities concerned as well as the local people to take suitable measures needed for restoring the health of this polluted area and in preserving the pristine nature of this creek besides sustainable utilization of its resources. The fisher folk of four Grama Panchayats namely Chavara, Thekkumbhagam, Thevalakkara and Neendakara are benefitting from this bioreserve. The total extent of the fragile lake zone has shrunk to an area of 44.77 Km^2 from an original of 53.89 km^2. This estuary is one of the foremost centers of marine fish production and landings along the Kerala coast. Many fish species get extinct due to lack of spawning facilities on the banks of the lake due to fortification of the shore of the lake by walls built of laterite and granite stones a perusal of literature shows that no sufficient study was carried out on the eco-biology of Thekkumbhagam Creek of Ashtamudi estuary. The surface water salinity values were found to be lower than that of bottom water. Higher salinity value reaching up to a maximum of 38.09 ppt observed during the month of December may be due to low rainfall, decreased fresh water inflow, land drainage and rise in temperature. Variations in salinity produce changes in species composition, distribution and abundance in an estuary. The investigation also point out the need for a regular monitoring of the salinity fluctuations of the estuary.

Keywords: Creek, Ashtamudi, Thekkumbhagam, salinity etc

1. Introduction

Declining water quality is an acute problem around the world, particularly in developing countries where there are notable increase in agricultural and industrial pollution coupled with a lack of adequate waste water treatment. Located in the beautiful southern Indian state of Kerala, the Ashtamudi estuary is an extensive palm shaped water body that lies in the district of Kollam. This estuary is replenished with fresh water brought by the Kallada River which originates in the Western ghat region. The calm waters of this creek, together with the reflection of the surrounding coconut plantations and the lush green vegetation all around, creates a landscape of breathtaking beauty rarely seen elsewhere.

Even though this region is the cradle for post larvae of shrimps, crabs and also the fry and fingerlings of marine and brackish water fishes (Madhusoodana Kurup *et al*., 2001) [4], the indiscriminate exploitation of these wetlands in the name of development well beyond its supportive capacity and input of waste products exceeding the assimilative capacity, pollutes this wetland system of Kerala. The knowledge on the hydrographic parameters of an estuarine environment is of great importance while attempting to characterize its general features, distribution pattern of various pollutants, salinity intrusion, abundance of nutrients etc. The main factors influencing the hydrographic conditions of an estuary are the saline water intrusion associated with tides and the freshwater brought in by the rivers. Salinity has been viewed as one of the most important variables influencing the utilization of organisms in estuaries (Marshall and Elliot, 1998) [5].

Four locations in the Thekkumbhagam creek of Ashtamudi estuary were selected for the determination of salinity variations from June 2008 to May 2010. This estuarine system is largely influenced by the influx of fresh water, which in turn is controlled by the monsoon season facilitating the division of observation period into three distinct periods namely

pre-monsoon (Feb-May),monsoon (June-Sept), post-monsoon (Oct-Jan). The ultimate purpose of this work is to conserve the entire complement of species, habitats and processes so that the ecological functions can be sustained.

2. Materials and Methods

Monthly water samples of surface and bottom for hydrographical studies have been made from four selected sites of Thekkumbhagam creek of Ashtamudi estuary in Kollam district for a period of two years (From June 2008 to May 2010). Maximum care was taken in collecting, preserving storing and analyzing the samples. Salinity estimations were carried out following the Mohr method in which the halogen ions are titrated with AgNO3 using potassium dichromate as indicator. 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.

3. Results

The results of the present study are furnished in Table 1.1 and fig 1.1a, 1.1b, 1.1a, 1.1b**.**

In station 1, the salinity (ppt) of surface water ranged from 6.5ppt to 35.07ppt in 2008-2009 and from 8.15 to 38.09 in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 13.44 ± 1.45, 16.09 ± 6.58, 17.39 ± 3.62 respectively in the first year and 13.64 ± 1.43, 19.77 ± 6.48, 17.52 ± 4.07 ppt, respectively in the second year. The annual mean ± SE was 15.64 ± 2.36 ppt,in 2008-2009 and 16.98 ± 2.47ppt, in 2009-2010.In station 1,the salinity of bottom water ranged from 8.5ppt to 25.3ppt in 2008-2009 and from 8 to 27.3 ppt in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 16.66 ± 3.12, 14.19 ± 3.78, 15.59 ± 0.31ppt, respectively in the first year and 16.45 ± 3.2, 16.54 ± 4.13, 15.59 ± 0.52 ppt, respectively in the second year. The annual mean ± SE of salinity was 16.09 ± 6.58 ppt in 2008-2009 and 16.19 ± 1.59 ppt in 2009-2010. (Table 1, 1 & fig 1.1a, 1.1b, 1.2a, 1.2b).

In station 2, the salinity (ppt) of surface water ranged from 8.15 to 19.5 in 2008-2009 and from 8.15 to 19.62 in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 10.86 ± 1.4, 12.93 ± 3.06, and 15.63 ± 0.65 ppt, respectively in the first year and 11.02 ± 1.4, 14.66 ± 2.26, 15.77 ± 0.83 ppt in the second year. The annual mean ± SE was 13.14 ± 1.19 ppt in 2008-2009 and 13.8 ± 8.8 ppt in 2009-2010.In station 2, the salinity of bottom water ranged from 7.12 to 24.18 ppt in 2008-2009 and from 7.11 to 25.2 ppt in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 14.24 ± 3.14, 14.22 ± 2.58, and 19.71 ± 1.55 ppt, respectively in the first year and 14.41 ± 3.15, 15.13 ± 2.31, 20.82 ± 1.52 ppt, respectively in the second year. The annual mean ± SE was 14.22 ± 2.58ppt in 2008-2009 and 16.78 ± 1.53 ppt in 2009-2010.

In station 3, the salinity of surface water ranged from 6.6 to 7.7 ppt in 2008-2009 and from 1 to 20.73 ppt in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 7.74 ± 2.64, 8.66 ± 4.39ppt, and 15.46 ± 1.36 ppt, respectively in the first year and 7.84 ± 2.56, 11.07 ± 3.72, 17.25 ± 1.76 ppt, respectively in the second year. The annual mean ± SE was 10.62 ± 1.91ppt, in 2008-2009 and 12.05 ± 1.88 ppt in 2009-2010.In station 3, the salinity of bottom water ranged from 6 to 20.73 ppt in 2008-2009 and from 6.5 to 21.73ppt in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 8.41 ± 1.54, 12.15 ± 2.89 ppt, and 16.4 ± 1.28 ppt, respectively in the first year and 8.74 ± 1.39, 12.38 ± 3.27, 16.28 ± 1.22 respectively in the second year. The annual mean ± SE was 12.32 ± 1.45ppt in 2008-2009 and 12.05 ± 1.46 ppt in 2009-2010.

In station 4, the salinity of surface water ranged from 2.5 to 35ppt in 2008-2009 and from 2.7 to 36.07 ppt in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 8.67 ± 2.22, 15.46 ± 4.32 ppt, and 18.62 ± 5.59 respectively in the first year and 8.88 ± 2.29, 16.51 ± 3.91, 19.24 ± 5.74 ppt, respectively in the second year. The annual mean ± SE was 14.25 ± 2.56 in 2008-2009 and 14.87 ± 2.57 in 2009-2010.In station 4, the salinity of bottom water ranged from 7.3 to 31.5ppt in 2008-2009 and from 7.5 to 31.6 ppt in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 9.7 ± 1.17, 17.59 ± 5.22, and 16.65 ± 0.88ppt, respectively in the first year and 10.13 ± 1.14, 18.62 ± 4.75, 17.55 ± 0.97 ppt, respectively in the second year. The annual mean ± SE was 14.65 ± 1.94 ppt in 2008-2009 and 14.65 ± 1.94 ppt in 2009-2010.

Table 1: Salinity (ppt) of water collected from different stations of Thekkumbhagam creek of Ashtamudi estuary during the three seasons of the year, 2008-2010.

Year	Season	Month	Salinity (ppt)							
			Station 1		Station 2		Station 3		Station 4	
			Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
2008-2009	Monsoon	JUN	14.12	16.23	11.16	15.12	14.12	12.69	11.16	12.19
		JUL	10.89	14.62	8.15	7.12	8.15	6	12.5	8.15
		AUG	11.5	10.5	9.5	12.5	1.2	6.3	8.5	7.3
		SEP	17.23	25.3	14.62	22.22	7.5	8.65	2.5	11.16
	Post-Monsoon	OCT	8	8.5	8.5	9.5	3	8.1	7.3	9.5
		NOV	6.5	10.15	7	10.16	5.5	9.65	9.15	9.65
		DEC	35.07	25.2	16.73	19.73	21.73	20.73	20.23	19.73
		JAN	14.8	12.89	19.5	17.5	4.4	10.15	25.17	31.5
	Pre-Monsoon	FEB	14.12	16.12	16.12	24.18	16.62	18.63	35.07	16.23
		MAR	28.2	15.73	17.13	17.13	12.2	14.24	10.18	19.23
		APR	13.12	14.71	14.12	19.21	18.5	14.13	15.11	15.82
		MAY	14.11	15.81	15.13	18.31	14.5	18.6	14.12	15.34
2009-2010	Monsoon	JUN	14.62	16.73	11.66	15.62	14.12	12.69	11.66	12.69
		JUL	11.05	13.12	8.15	7.11	8.15	7.11	12.69	9.15
		AUG	11.66	10.66	9.66	12.69	1.6	6.5	8.65	7.5
		SEP	17.23	25.3	14.62	22.22	7.5	8.65	2.5	11.16

	Post-Monsoon	OCT	8.15	8	8.65	9.15	1	6.5	7.5	9.65
		NOV	18.73	18.23	15.12	14.5	10.66	11.13	14.12	14.12
		DEC	38.09	27.23	15.23	20.15	18.5	21.73	18.23	19.15
		JAN	14.12	12.69	19.62	16.73	14.12	10.15	26.17	31.57
	Pre-Monsoon	FEB	15.12	16.23	15.12	25.2	15.62	19.73	36.07	17.23
		MAR	29.61	16.73	18.23	18.23	13.12	14.12	10.16	20.23
		APR	13.19	14.62	14.62	20.23	20.73	15.12	15.12	15.62
		MAY	12.18	14.8	15.12	19.62	19.53	16.15	15.62	17.12

Table 1.1: ANOVA for difference in salinity of surface water between the stations and seasons

	2008-2009			2009-2010		
Source	**Sum of squares**	**Mean Sum of squares**	**F**	**Sum of squares**	**Mean Sum of squares**	**F**
Total	2425.10			2436.00		
Between stations	162.40	54.10	1.80	152.60	50.90	1.40
Between seasons	348.50	174.30	5.71**	431.00	215.50	6.09**
Periods within seasons	906.93	100.77	3.3**	685.67	76.19	2.15
Error	1007.25	30.52		1167.28	35.37	

Table 1.2: ANOVA for difference in salinity 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	1548.50			26533600.00		
Between years	10.80	10.80	1.60	4963360.00	4963360.00	5.1*
Between seasons	93.10	46.50	7.08*	1744326.00	872163.00	0.89
Periods within seasons	1372.38	152.49	23.2**	9051016.00	1005668.00	1.03
Error	10774900.00	979536.40		10774900.00	979536.40	
	Station 3			**Station 4**		
Source	**Sum of squares**	**Mean Sum of squares**	**F**	**Sum of squares**	**Mean Sum of squares**	**F**
Total	4172677.00			540982700.00		
Between years	2620178.00	2620178.00	37.2**	64125760.00	64125760.00	3.00
Between seasons	26634.80	13317.40	0.19	87318650.00	43659320.00	2.01
Periods within seasons	751080.00	83453.64	1.18	150184566.00	16687174.00	0.77
Error	774784.00	70434.93		238388200.00	21671655.00	

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

Table 1.3: ANOVA for difference in salinity of bottom water between the stations and seasons

	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	1483.30			47	1525.00		
Between stations	3	97.00	32.30	1.90	3	132.50	44.20	2.50
Between seasons	2	187.30	93.60	5.56**	2	215.30	107.70	3.18
Periods within seasons	9	642.92	71.44	4.24**	9	602.23	66.91	3.84
Error	33	556.18	16.85		33	574.97	17.42	

Table 1.4: ANOVA for difference in salinity of bottom water between the years of study in stations

	Station 1				Station 2			
Source	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**
Total	23	638.4			23	18484320.00		
Between years	1	3.10	3.10	1.00	1	82251.00	82251.00	0.20
Between seasons	2	6.40	3.20	1.04	2	2512654.00	1256327.00	2.33
Periods within seasons	9	594.87	66.10	21.34**	9	9946394.00	1105155.00	2.05
Error	11	34.07	3.10		11	5943017.00	540274.30	
	Station 3				**Station 4**			
Source	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**	**DF**	**Sum of squares**	**Mean Sum of squares**	**F Ratio**
Total	23	2858166.00			23	317093900.00		
Between years	1	577437.00	577437.00	6.4*	1	10976900.00	10976900.00	1.50
Between seasons	2	22106.50	11053.30	0.12	2	92108170.00	46054080.00	6.28*
Periods within seasons	9	1263477.00	140386.30	1.55	9	133313310.00	14812590.00	2.02
Error	11	995145.90	90467.77		11	80662620.00	7332965.50	

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

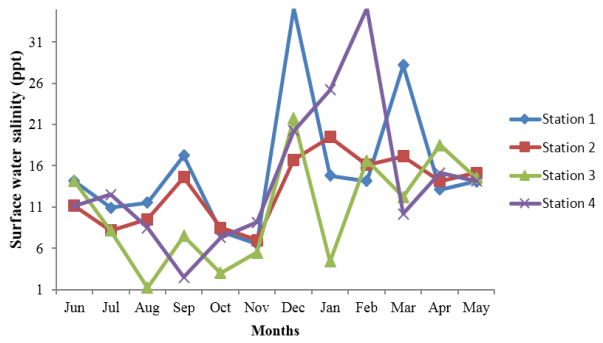

Fig 1.1a: Monthly variations of surface water salinity (2008-2009)

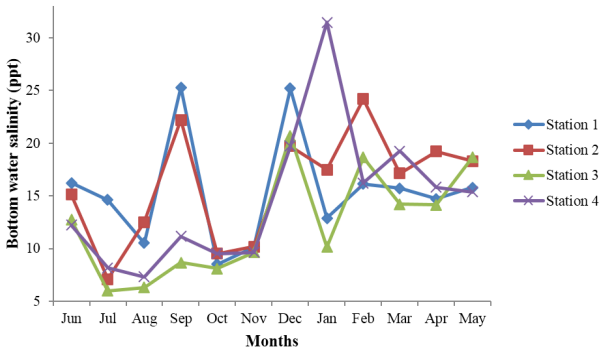

Fig 1.2a: Monthly variations of bottom water salinity (2008-2009)

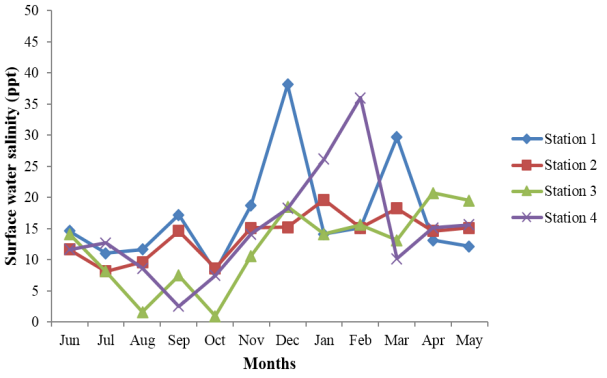

Fig 1.1b: Monthly variations of surface water salinity (2009-2010)

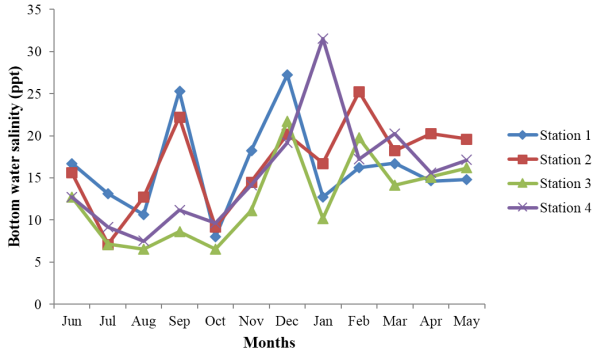

Fig 1.2b: Monthly variations of bottom water salinity (2009-2010)

Comparing ANOVA surface water salinity values of 2008-2009 showed variations between seasons, periods within seasons. But in the case of results of 2009-2010 showed variations significant between seasons at 1% level. For station 1 ANOVA comparing surface salinity values between the years of study showed significant variations between seasons at 1% level and for the periods within seasons significant at 5% level. In the case of station 2, showed significant variations between years at 5% level and station 3 showed variations between years at 1% level. ANOVA comparing bottom water salinity between stations in 2008-2009 showed significant variations observed between seasons and for period's within seasons at 1% level. While no significant variations in the case of 2009-2010. ANOVA for bottom water salinity between the years of study showed no significant variations in station 2. It showed variations between years significant at 1% level. Station 3 showed variations between seasons significant at 1% level. (Table 1.1, 1.2, 1.3, 1.4).

4. Discussion

Salinity varies in different ecosystems according to the topography, tides and fresh water inflow. The salinity of surface water ranged in the present work from 1.2 to 35 ppt and bottom 6 to 31.5 in the first year. Salinity surface from 2009-2010 is 2.5 to 38.09 in the first year and salinity bottom 7.1 to 31.07 in the second year. Salinity is one of the important factors that influence the functional physiology and reproductive activity of organisms. A slight change in salinity will affect the physical, chemical and biological factors of an aquatic ecosystem (Dehadri, 1970) [3].Salinity is one of the important factors which profoundly influence the abundance and distribution of the animals in estuarine environment and inshore water. From the study, it was recorded that the maximum salinity value was recorded during summer may be due to the highest degree of evaporation in the study area. The low values found during October were due to heavy rainfall and large quantity of fresh water inflow. Similar trends in the salinity values were also reported from various parts in south east coast of India by Sreenivasan (1996); Palanichamy and Rajendran (2000) [8]; Prabhu *et al*,.(2000) [9]; Sulochana and Muniyandi (2005) [11]; Soundarapandian *et al.,* (2009) [10], Damotharan *et al.,* (2010) [2].

Higher salinity up to 38.09 ppt may be due to domestic discharges, industrial wastes, slaughter house wastes etc. Minimum salinity reaching up to 1.5ppt and 2ppt in the month of August and October during the 2008-2009 periods might be due to the heavy rainfall available at that period. Mc Lusky (1989) [6] reported that rainfall could cause dilution of estuaries and hence cause reduction in salinity, while heat generated by sunlight in dry season months would cause evaporation of the surface water making it saltier and hence more saline. The surface salinity values were found to be lower than that of bottom in the sites indicating the prevalence of density stratification within the estuary. The difference in the surface and bottom salinity can also be due to the out flowing riverine water giving a two layered structure (Nasnolkar *et al*., 1996) [7].The above reports agrees with the present study. Higher salinity value reaching up to a maximum of 38.09 ppt during the month of December may be due to low rainfall, decreased fresh water inflow, land drainage and rise in temperature etc. Variations in salinity produce changes, in species composition, distribution and abundance in an estuary. Salinity is also important because it affects chemical conditions within the estuary particularly dissolved oxygen solubility decreases with increasing salinity. The high salinity values recorded during rainy seasons may be attributed to factors such as days of sampling, time of sampling and nature of effluents discharged to the sampling stations before or during sampling. (Abowei, 2010) [1].

5. Conclusion

Salinity is considered to be the prime factor among the environmental variables influencing the dynamic nature of the estuarine and coastal waters since salinity plays a key role in the dynamics of an estuarine ecosystem. The prevalence of wide salinity variations is a characteristic feature of the back waters. Variations in salinity produce changes in species composition, distribution and abundance in an estuary. Salinity is also important because it affects chemical conditions within the estuary, particularly dissolved oxygen levels. The amount of dissolved oxygen (solubility) decreases with increasing salinity. The primary classes of salinity are fresh water (0-0.5 parts per thousand), brackish water, (0.5-30 ppt) and salt water (more than 30 ppt). With respect to the study conducted the mean value of salinity was maximum during the post-monsoon season in the station 1. This may be so as the salinity levels in estuaries are generally highest near the mouth of river where sea water enters and lowest upstream where fresh water flows. Overall salinity levels in the spring when snowmelt and rain produce elevated fresh water discharges from rivers and ground water. Salinity is thus an important hydrographic parameter affecting growth, distribution, species succession and productivity in the aquatic environment especially in estuary that is more susceptible to variations. Thus salinity is considered as the most outstanding chemical property of the estuarine waters. These water resources have tremendous value to humans and should be protected since we have benefitted tremendously from an environment rich and varied in biological resources .

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