EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 Volume 2 Number 7 (July-2015) pp. 178-184

www.ijcrbp.com

Original Research Article

A Study on the Dissolved Oxygen Content of Thekkumbhagam Creek of Ashtamudi Estuary

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Abstract

Estuaries, like the rest of the world are still not adequately protected from human disturbances. The rapid industrialization and the aquaculture practices along the river systems and the coastal areas have brought considerable decline in the water quality of brackish water and the estuaries. 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. The creek has a good resource of fishes, prawns, crabs and clams and provides livelihood to thousands of people. Main sources of pollution include oil spillage from fishing boats of Neendakara, industrial wastes, coconut husk retting, untreated sewage, and human excreta etc. Having recognized the importance of this estuary a comprehensive monitoring and an evaluation of the dissolved oxygen concentration of the estuary is inevitable. So in the present study it is proposed to make an investigation on the dissolved oxygen concentration of four selected stations of Thekkumbhagam Creek of Ashtamudi Lake. It was observed that estuary experienced certain periods with a complete lack of dissolved oxygen. The main motive behind this study is to bring out the changes in the dissolved concentrations that are leading to the ecological degradation of the Thekkumbhagam creek.

Keywords

Ashtamudi

Creek

Dissolved oxygen

Water quality

Introduction

Water, the most vital source for all kinds of life on this planet, is also the resource, adversely affected both qualitatively and quantitatively by all kinds of human activities on land, in air or in water. So monitoring the health of coastal and estuarine ecosystems has become increasingly important over the past decades. As human activities continue to affect these waters, the nation is becoming more aware of the need to take a more comprehensive approach to protect freshwater and marine resources. The rapid industrialization and the aquaculture practices along the river systems and the coastal areas have brought considerable decline in the water quality of brackish water and the estuaries (Sundaramanickam et al., 2008). The environmental conditions such as topography, water movement, oxygen, temperature, transparency and free carbon dioxide characterizing particular water mass, also determine the composition of its biota (Karande, 1991).

The present study analyses dissolved oxygen content of Ashtamudi estuary, one of the largest and deepest wetland ecosystems. It also addresses the possible sources (natural and anthropogenic) of water quality parameters. Four locations in the Thekkumbhagam creek of Ashtamudi estuary were selected for the determination of Dissolved oxygen of surface and bottom water samples, 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 study will give an idea about the variations associated with the dissolved oxygen concentrations as a result of anthropogenic activities and would make aware of the need for the proper conservation of the Thekkumbhagam creek as the sustainability of the lives of the people around this creek is entirely dependent on the health status of this region. 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. 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.

Materials and methods

Monthly collection of surface and bottom water samples for estimation of dissolved oxygen 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), covering three prominent seasons of the year (pre-monsoon, monsoon and post-monsoon).

Maximum care was taken in taking samples, their preservatives, storage and analysis. Fixation of dissolved oxygen was done at the site itself. Dissolved oxygen was determined by Winkler's Iodometric method (APHA, 1985). 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.

Results and discussion

In station1, the dissolved oxygen of surface water ranged from 2 to 7.5 mg/l in 2008-2009 and from 2.08 to 7.68mg/l in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 4.89 ± 1.17, 4.42 ± 0.47, 4.44 ± 0.39 respectively in the first year and 4.94 ± 1.18, 4.6 ± 0.44, 4.52 ± 0.36 respectively in the second year. The annual mean ± SE was 4.59 ± 0.04 in 2008-2009 and 4.68 ± 0.4 in 2009-2010 (Tables 1 and 2 and Fig. 1 a, b). In station 1, the dissolved oxygen of bottom water ranged from 2.64 to 6.88 mg/l in 2008-2009 and from 2.56 to 7.12 mg/l in 2009-2010. The mean values during monsoon, post-monsoon, pre-monsoon were 4.2 ± 0.72, 5.25 ± 0.55, 4.66 ± 0.16 respectively in the first year and 4.1 ± 0.75, 4.95 ± 0.78, 4.64 ± 0.09 respectively in the second year. The annual mean ± SE was 4.7 ± 0.31 in 2008-2009 and 4.56 ± 0.34 in 2009-2010 (Table 3 and 4; Fig 2a, b).

In station 2 ,the dissolved oxygen of surface water ranged from 2.16 to 7.04mg/l in 2008-2009 and from 2.4 to 7.04 in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 5.6 ± 0.58, 5.33 ± 0.86, and 3.28 ± 0.69 respectively in the first year and 5.7 ± 0.62, 5.86 ± 0.86, 3.2 ± 0.64 respectively in the second year. The annual mean ± SE was 4.74 ± 0.49 in 2008-2009 and 4.92 ± 0.52 in 2009-2010.

In station 2, the dissolved oxygen of bottom water ranged from 1.68 to 5.92 mg/l in 2008-2009 and from 1.7 to 5.84 in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 4.72 ± 0.63, 4.66 ± 0.48, and 3.06 ± 0.46 respectively in the first year and 4.82 ± 0.61, 5.34 ± 1.24, 3.23 ± 0.54 respectively in the second year. The annual mean ± SE was 4.15 ± 0.36 in 2008-2009 and 4.46 ± 0.52 in 2009-2010. In station 3, the dissolved oxygen of surface ranged from 0.4 to 5.68 mg/l in 2008-2009 and from 1.52 to 6.16mg/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 2.21 ± 0.69, 3.66 ± 0.75, and 2.22 ± 0.5 respectively in the first year and 3.06 ± 0.39, 4.28 ± 1, 2.82 ± 0.52 respectively in the second year. The annual mean ± SE was 2.69 ± 0.39 in 2008-2009 and 3.39 ± 0.41 in 2009-2010.

In station 3, the dissolved oxygen of bottom water ranged from 1.04 to 6.08 mg/l in 2008-2009 and from 0 to 6.96mg/l in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 2.52 ± 0.84, 5.56 ± 0.42, and 2.36 ± 0.67 respectively in the first year and 2.6 ± 0.87, 5.24 ± 0.65, 4.3 ± 1.58 respectively in the second year. The annual mean ± SE was 3.48 ± 0.56 in 2008-2009 and 4.05 ± 0.67in 2009-2010.

Table 1 (a). Dissolved oxygen (mg/l) of water (2008-2010).

Year	Season	Month	Dissolved oxygen (mg/l)							
			Station 1		Station 2		Station 3		Station 4	
			Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
2008-2009	Monsoon	JUN	4.32	3.44	5.92	2.88	3.28	3.28	0.24	0
		JUL	2	2.64	6.88	5.04	3.28	3.44	1.84	0
		AUG	7.52	4.88	5.52	5.76	0.4	0	1.84	2.72
		SEP	5.75	5.84	4.08	5.2	1.88	3.36	2.56	6.48
	Post-Monsoon	OCT	4.88	6.88	6.48	5.92	5.68	6.8	2.48	2.72
		NOV	4.24	4.56	4.44	4.72	3.92	5.2	2	3.6
		DEC	3.2	4.6	7.04	4.4	2.48	5.04	2.6	4.8
		JAN	5.36	4.96	3.36	3.6	2.56	5.2	2.48	3.04
	Pre-Monsoon	FEB	5.44	5.04	5.28	3.44	3.6	4.24	1.12	3.36
		MAR	3.52	4.24	2.16	1.68	2.32	1.04	1.76	3.92
		APR	4.32	4.64	2.72	3.52	1.36	2	0	0
		MAY	4.48	4.72	2.96	3.6	1.6	2.16	0	0
2009-2010	Monsoon	JUN	4.24	3.2	6.08	3.04	3.44	3.44	0.32	0
		JUL	2.08	2.56	7.04	5.2	3.44	3.6	1.92	0
		AUG	7.68	4.8	5.6	5.84	3.48	0	1.92	2.88
		SEP	5.76	5.84	4.08	5.2	1.88	3.36	2.56	6.48
	Post-Monsoon	OCT	4.88	7.12	6.56	5.44	5.84	6.96	2.56	2.8
		NOV	4.56	3.4	6.8	3.68	6.16	3.84	3.68	2.4
		DEC	3.44	4.48	6.8	8.8	2.4	4.8	2.48	4.8
		JAN	5.52	4.8	3.28	3.44	2.72	5.36	2.4	2.96
	Pre-Monsoon	FEB	5.6	4.8	5.12	4.24	3.44	4.16	1.2	3.2
		MAR	3.68	4.4	2.4	1.7	2.48	8.8	1.6	4.16
		APR	4.48	4.72	2.56	3.36	1.52	1.84	0	0
		MAY	4.32	4.64	2.72	3.6	3.84	2.4	0	0

Table 1 (b). ANOVA testing Dissolved Oxygen of surface water between the stations and seasons.

Source	2008-2009			2009-2010		
	Sum of squares	Mean Sum of squares	F Ratio	Sum of squares	Mean Sum of squares	F Ratio
Total	169.10			171.90		
Between stations	84.10	28.00	16**	77.70	25.90	15.7**
Between seasons	14.00	7.00	4*	20.40	10.20	6.19**
Periods within seasons	13.10	1.46	0.83	19.42	2.16	1.31
Error	57.80	1.75		54.34	1.65	

In station 4, the dissolved oxygen of surface water ranged from 0.24 to 2.6 in 2008-2009 and from 0.32 in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 1.62 ± 0.49, 2.39 ± 0.13, and 0.72 ± 0.44 respectively in the first year and 1.68 ± 0.48, 2.78 ± 0.3, 0.7 ± 0.44 respectively in the second year. The annual mean ± SE was 1.58 ± 0.29 in 2008-2009 and 1.72 ± 0.33 in 2009-2010.

In station 4, the dissolved oxygen of bottom water ranged from 0 to 6.48 mg/l in 2008-2009 and from 0 to 6.96 in 2009-2010. The mean values during monsoon, post-monsoon and pre-monsoon were 2.3 ± 1.53, 3.54 ± 0.46, and 1.82 ± 1.06 respectively in the first year and 2.34 ± 1.54, 3.24 ± 0.53, 1.84 ± 1.08 respectively in the second year. The annual mean ± SE was 2.55 ± 0.62 in 2008-2009 and 2.47 ± 0.61 in 2009-2010.

ANOVA comparing dissolved oxygen of surface water between stations (2008-2009) showed variations between stations significant at 1% level and between seasons significant at 1%level and between seasons significant at 5% level. For the second year it showed variations between stations and seasons significant at 1% level. ANOVA comparing dissolved oxygen of surface water between the years of study for station 1 showed significant variations between seasons and for periods within seasons at 1%level and between years significant at 5% level. ANOVA comparing dissolved oxygen of bottom water between stations showed variations between stations and seasons significant at it1% level for 2008-2009 while showed no significant variations for 2009-2010. ANOVA comparing the dissolved oxygen of bottom water between the years of study for station 1, revealed significant variations between seasons and periods within seasons significant at 1% level. But station 2 and station 3 showed variations between years significant at 1% level. Station 4 showed variations between years significant at 5% level).

Fig. 1a: Monthly variations of dissolved oxygen of surface water (2008-2009).

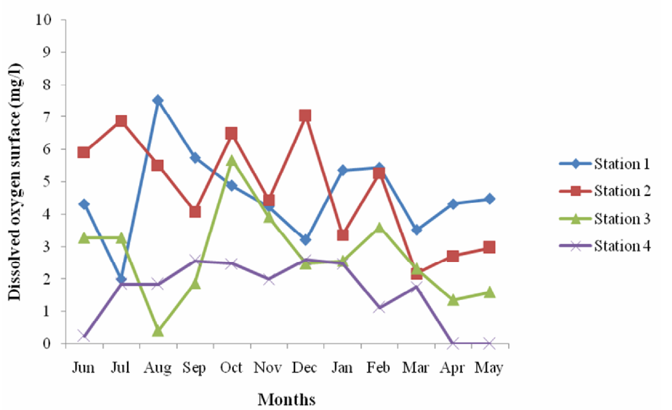
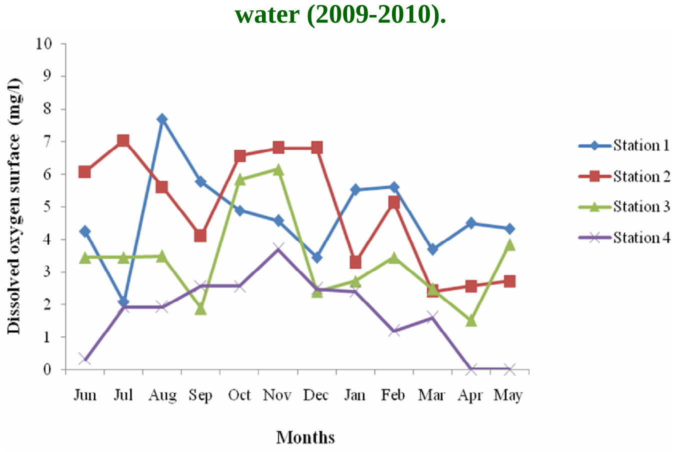


Fig. 1b: Monthly variations of dissolved oxygen of surface water (2009-2010).



In the present study, dissolved oxygen of surface water ranged between 0 to 7.52 mg/l and dissolved oxygen of bottom water from 0 to 6.88mg/l in the first year and dissolved oxygen of surface water was 0 to 7.68 mg/l and dissolved oxygen of bottom water from 0 to 7.12mg/l in the second year.

Mean values of dissolved oxygen of surface water reached maximum during the monsoon season while dissolved oxygen of bottom water showed a maximum value during post-monsoon period. Dissolved oxygen concentration was low during the pre-monsoon season but increased during summer and monsoon season. The low dissolved oxygen concentration observed during the pre-monsoon season could be attributed to the lesser input of fresh water in to the study area. Higher value of dissolved oxygen concentration observed in the monsoon was due to the heavy rainfall and the result of fresh water mixing. This was in agreement of the findings of Zingde et al. (1985); Ramaraju et al. (1987); Mitra et al. (1990); Nandan and Abdul Aziz (1994) and Rajasegar (2003).

In the monsoon season the estuary was dominated with fresh water flow from Kallada River and land run off, while in the non monsoon season, the water in the estuary showed predominantly saline characteristics. The concentration of hydrographic parameters was governed by river water flow, sea water intrusion and other input from different human activities, urban sewage, industrial effluents, and coconut husk retting etc. However, during the non monsoon season, a different context arises due to reduced flow through Kallada River together with the addition of different types of waste materials in large quantities which lead to the depletion of dissolved oxygen and subsequent non oxidation of organic materials.

Station 3 and station 4 exhibited mostly the less abundance of oxygen leading to anoxic condition noticed in certain months. This may be due to the uncontrolled deposition of domestic waste, slaughter house wastes, hospital wastes, plastic wastes, poultry wastes, retting activity, eco tourist waste etc. The decomposition of organic waste and oxidation of inorganic waste may reduce the dissolved oxygen to extremely low levels which may prove harmful to organisms in the aquatic environment. The depletion of oxygen content in water lead to undesirable obnoxious odours under anaerobic conditions (Nelson, 1978) and damage to aquatic life.

From the study it was observed that in some months the amount of dissolved oxygen in surface waters is usually greater than that in bottom water. This may be attributed to the partial utilization of dissolved oxygen by organic rich sediments. The variation in the amount of dissolved oxygen is also attributed to the seasonal and tidal fluctuations of both surface and bottom waters (Pillai et al., 1975). High monsoonal values decreased as the season advanced to post-monsoon and pre-monsoon. Similar patterns in the variation of dissolved oxygen were reported in other estuaries (Kumaran and Rao, 1975). Low values recorded during pre-monsoon may be due to the discharging effluents and low solubility of oxygen in high saline water. Dissolved oxygen less than 2.5mg/l was discovered to be hypoxic (Laponite and Clark, 1992).

Table 2. ANOVA testing Dissolved Oxygen of surface water between the years of study in stations.

Source	Station 1			Station 2		
	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	42.90			5185675.00		
Between years	0.10	0.10	6.6*	916546.80	916546.80	5.2*
Between seasons	1.00	0.50	51.78**	350409.50	175204.80	0.98
Periods within seasons	41.76	4.64	499.9**	1961176.00	217908.00	1.22
Error	0.10	0.01		1957543.00	177958.50	
Source	**Station 3**			**Station 4**		
	Sum of squares	**Mean Sum of squares**	**F**	**Sum of squares**	**Mean Sum of squares**	**F**
Total	1295753.00			78273620.00		
Between years	287667.40	287667.40	5.5*	8002445.00	8002445.00	2.60
Between seasons	228920.00	114460.00	2.20	13892580.00	6946290.00	2.22
Periods within seasons	206971.80	22996.86	0.44	22017600.00	2446400.00	0.78
Error	572193.90	52017.63		34361000.00	3123727.30	

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

Table 3. ANOVA testing Dissolved Oxygen of Bottom water between the stations and seasons.

Source	2008-2009			2009-2010		
	Sum of squares	Mean Sum of squares	F Ratio	Sum of squares	Mean Sum of squares	F Ratio
Total	152.80			193.70		
Between stations	30.80	10.30	5.1**	33.70	11.20	3.90
Between seasons	27.20	13.60	6.82**	15.60	7.80	2.71
Periods within seasons	28.85	3.21	1.60	49.12	5.46	1.89
Error	65.96	2.00		95.21	2.89	

Table 4. ANOVA testing Dissolved Oxygen of Bottom water between the years of study in stations.

Source	Station 3			Station 4		
	Sum of squares	Mean Sum of squares	F Ratio	Sum of squares	Mean Sum of squares	F Ratio
Total	26142720.00			43611780.00		
Between years	9279707.00	9279707.00	11.3**	13086100.00	13086100.00	9.2*
Between seasons	1866433.00	933216.50	1.14	3990062.00	1995031.00	1.41
Periods within seasons	5993504.00	665944.90	0.81	10942722.00	1215858.00	0.86
Error	9003072.00	818461.10		15592900.00	1417536.40	

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

Another reason for the lesser oxygen content in the bottom water may be i.e. higher value at the surface could be due to higher photosynthetic activity at the euphotic zone, the inputs from the atmosphere and higher solubility of oxygen in the lower salinity surface water. The lower dissolved oxygen might be attributed to the low solubility of oxygen in saline waters and supports with the previous studies conducted by Sankaranarayanan and Panampunnayil (1979).

Thus oxygen distribution provides a good index of productivity and quality of the environment. Higher oxygen concentration is indicative of higher photosynthetic efficiency and phyto plankton production. Main source of oxygen is aquatic plants, that also provides atmosphere, but during photosynthesis oxygen may fall to unhealthy levels if water is polluted (Clark, 1996). Dissolved oxygen depletion could suppress respiration cause death of fish, depress feeding or affect embryonic development and hatching success due to oxygen starvation. This could lead to reproductive failures, changes in the composition, abundance and diversity of species at the community level. Thus dissolved oxygen concentration determination is regarded as one of the best methods to assess water quality.

Fig. 2a: Monthly variations of dissolved oxygen of bottom water (2008-2009).

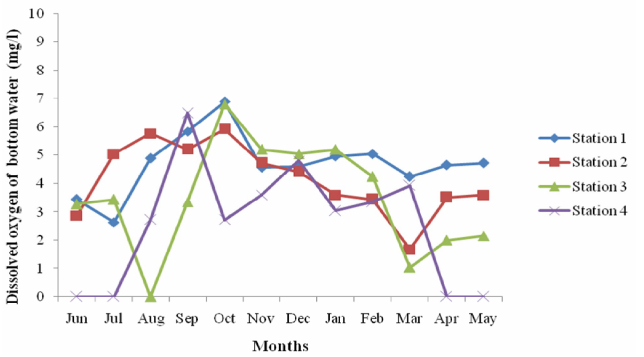
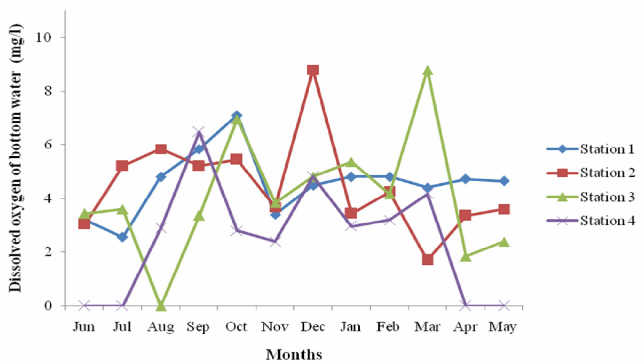


Fig. 2b: Monthly variations of dissolved oxygen of bottom water (2009-2010).



Conclusions

Oxygen is a key parameter of interest in water quality monitoring, because nearly all aquatic life needs oxygen to survive. The source of oxygen in water is atmospheric aeration and photosynthesis while the routes of oxygen removal or the “oxygen sinks” are respiration, decomposition of organic matter and losses to atmosphere. Coastal waters typically require a maximum of 40 mg/l and also do better with 5mg/l of oxygen to provide ecosystem function and highest carrying capacity. While dissolved oxygen levels from 1-3 mg/l indicate hypoxic condition and dissolved oxygen below 1 mg/l indicates anoxia, a condition in which no life that requires oxygen can be supported.

Dissolved oxygen is perhaps the most important limiting factor in aquatic ecosystems because most organisms other than microbes perish rapidly when dissolved oxygen level in water falls to zero. It is the most important parameter which can be used as an index for water quality, primary production and pollution. Dissolved oxygen concentration greater than 5 mg/l are considered “good” by the national estuary programmed, where as dissolved oxygen levels below 5 mg/l are typically either stressful or lethal to most aquatic organisms. The minimum acceptable limit of dissolved oxygen for fish life is 3 mg/l. Thus the measurement of dissolved oxygen and monitoring the changes in dissolved oxygen as a function of time and depth is essential to any study to aquatic ecology because it reflects the status of the dissolved oxygen balance, in turn reflecting the health of ecosystem.

Acknowledgement

The author is extremely grateful to the Zoology department of Sree Narayana College for the facility rendered during the tenure work.

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