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Seasonal variations of physico-chemical parameters in Shirgaon estuary of Ratnagiri, Maharashtra

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Abstract
The present study was undertaken to study the relation of physico-chemical water parameters of five sampling stations of Shirgaon estuary along the Ratnagiri coast from February 2013 to January 2014. Variation in atmospheric temperature 17.9-39.7 ^{0}C, water temperature 19.7 -35.1 ^{0}C, pH varied from 5.3-8.1, light penetration varied from 1-24 cm, salinity varied from 0-28.7 psu, dissolved oxygen varied from 0.4-4.8 mgl^{-1}, alkalinity varied from 3-80mgl^{-1}, nitrate varied from 0.000323-0.00154 µMl^{-1}, nitrite varied from0.000052-0.000208 µMl^{-1}, phosphate varied from 0.00253-0.000515 µMl^{-1}, silicate varied from 0.00129-0.000503 µMl^{-1}.

Keywords: Physico-chemical, five sampling stations, Maharashtra

Introduction
Estuaries are the meeting place of saltwater from the sea and freshwater from rivers, are dynamic environments characterized by large fluctuations in environmental conditions. Estuaries and mangroves are highly potential for fishery development in the aquatic environment and are considered as the potential source for feeding, spawning and nursery ground for most of the fin fishes and shellfishes (Vijaykumar *et al.*, 2014) [22].
Estuarine environmental study has accelerated during the past two decades since estuaries support a rich pelagic, benthic communities and serves as excellent nursery and feeding grounds for many commercially important fishes and shrimps (Ganapati, 1975) [6]. They also form the centres for natural seed collection of most of the commercially important fin fishes and shell fishes suitable for aquaculture. The faunal distribution and productivity of estuary depend on various physico-chemical factors such as temperature, pH, salinity, DO, water transparency and nutrients such as nitrate, phosphate and silicate. Fresh water is the finite resource essential for use in drinking, bathing, agriculture and industrial, propagation of wild life, fisheries and for domestic purpose. Clean water is essential for survival of all living organisms because synthesis of protein and other biological activities occurred in aqueous media.
Several investigations have been carried out on the physico-chemical features of southeast Indian estuaries *viz*., Uppanar estuary (Nedumaran *et al.*, 2011) [13], Pichavaram mangroves (Ashok Prabu, 2008) [3], Vellar estuary (Rajasegar, 2003) [3], Kaduviyar estuary (Vengadesh Perumal *et al.*, 2009) [20], Mulki estuary (Vijayakumar, 2000) [9] and Pennar estuary (Ravaniah *et al.*, 2010) [16]. No paper has been published on the physico-chemical characteristics in Shirgaon estuary Ratnagiri. Hence the present study was conducted to study the physico-chemcial parameters of water in the Shirgaon estuary, southwest coast of India.

Materials and Methods
To study the seasonal variation of physicochemical characteristics of Shirgaon estuary was selected. For the present study, five different locations were selected and water is collected for a period of twelve months from February 2013 to January 2014 covering, pre-monsoon (February -May), Monsoon (June-September), Post-monsoon (October-January) seasons. In the present study, monthly *in situ* sampling was carried out during high tides, by fixing stations from upper to lower reaches of estuary. A total of five stations were fixed in the estuary. Assessment of water parameters was carried out from the estuarine water.These samples were preserved in 5% formalin and used for further analysis (Santhanam *et al.*, 1987; Newell and Newell, 1963; AOAC, 2006 and APHA, 2005) [18, 1, 2]. Physico-chemical parameters such as

atmospheric and surface water temperatures, light penetration in the water column, salinity, dissolved oxygen and pH were recorded during the sampling. Nutrients like inorganic phosphate, nitrate, nitrite and silicate were analysed by adopting the standard methods (Strickland and Parsons, 1972) [19]. Physico-chemical parameters such as atmospheric and surface water temperatures in the water column collected using a centigrade mercury thermometer with an accuracy of 0.1 0C and expressed in degree Celsius, water transparency was estimated using sechhi disc (20 cm) in diameter, salinity of water samples was estimated using refractometer (Erma Hand Refractometer) with an accuracy of 0.1 ppt, The in situ water samples were collected carefully in DO bottles avoiding air bubble and fixed in the field for dissolved oxygen by using Winkler's method (Strickland and parsons, 1972) [19]. pH was estimated using pH meter (WTW pH 320) having an accuracy of 0.1, The collected water samples for alkalinity were analysed by titration method using standard procedure (Strickland and Parsons, 1972) [19]. Nutrients like inorganic phosphate, nitrate, nitrite and silicate were analysed by adopting the standard procedure (Strickland and Parsons, 1972) [19] using spectrophotometer (Genasys 10 UV).

Map 1: Sampling locations at Shirgaon estuary Ratnagiri, Maharashtra

Results and Discussion

Atmospheric temperature (^{0}C)

Atmospheric temperature is a function of the modification of solar radiant energy by air, clouds, land, sea and other water surfaces. Itis one of the important factors in the ecosystem, which may influence the distribution and abundance of flora and fauna. The monthly maximum atmospheric temperature was recorded in the month of May (39.7 ^{0}C) which could be attributed to high solar radiation in summerand minimum in month the December (17.9 ^{0}C) which may be because of low solar radiations in winter season (Fig. 1) (Table 1).Similar observation also recorded by (Kumary *et al.*, 2007) [11]. Similar observation was observed by (Bhaware *et al.*, 2013) [4]. Positive significant correlation coefficient was found between water temperature and atmospheric temperature (r = 841) (Table 2) (Hotekar *et al.*, 2011) [8].

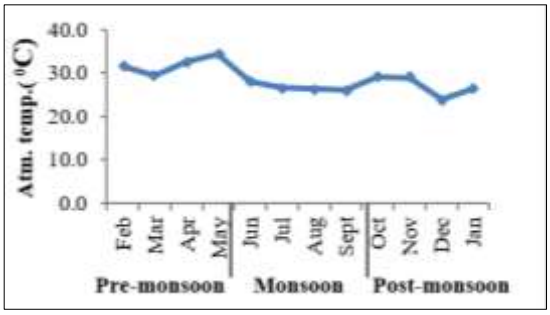

Fig 1: Monthly changes in atm. Temperature during 2013-14 in Shirgaon estuary

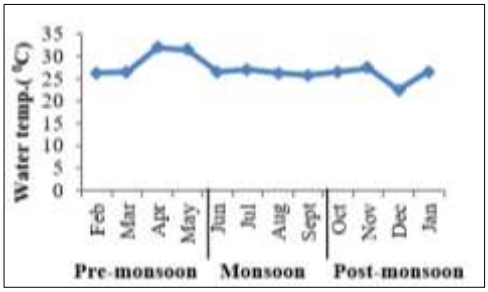

Fig 2: Monthly changes in water temperature during 2013-14 in Shirgaon estuary

Water temperature (^{0}C)

The seasonal variation in the water temperature may be associated with the wind force and atmospheric temperature. It is an important factor determining estuarine species habitat conditions. The maximum water temperature was recorded in the month April (35.1 ^{0}C) and minimum in the month December (19.7 ^{0}C) which might be influenced by the seasonal variations in intensity of solar radiation, evaporation, cooling with ebb and flow from adjoining neritic waters (Fig. 2) (Table 1).Water temperature of the estuary showed a positive correlation with salinity (r = .192) (Table 2) (Muthukumaravel *et al.*, 2012) [12].

pH

The pH is the measure of hydrogen ion (H+) concentration of a solution. It is the measure of the intensity of acidity or alkalinity of the sample. A seasonal variation of pH is shown in the table 3. The pH of water samples ranges from 6.9 to 7.47. The surface to bottom gradient of pH is more during monsoon due to flooding of fresh water in to the estuary, the estuary station shows slightly alkaline pH, the highest value (8.1) is observed in pre-monsoon season and lowest (5.3)in monsoon season. The fluctuations in pH values during different seasons of the year can be attributed to factors like removal of $CO_2$by photosynthesis through bicarbonate degradation, dilution of estuarine waters by freshwater influx and decomposition of organic materials (Karuppasamyet *et al.*, 2000; Rajasegar, 2003) [9, 15] (Fig. 1) (Table 1).The pH found negative correlation with dissolved oxygen (r = -.048) (Fig. 2) (Muthukumaravel *et al.*, 2012) [12].

Light penetration (cm)

It is one of the important physical parameter which determines plankton productivity in the aquatic environment. The maximum light penetration was recorded during the monsoon in the month of July (24 cm) and minimum in the month of February (1 cm) during post-monsoon season. The recorded low summer value could be due to the high plankton production while high monsoon value could be due to the low plankton production. The vigorous mixing due to flooding condition in monsoon,

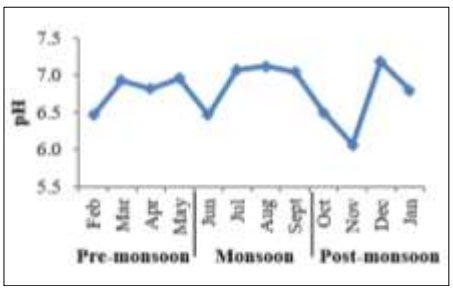

Fig 3: Monthly changes in pH during 2013-14 in Shirgaon estuary

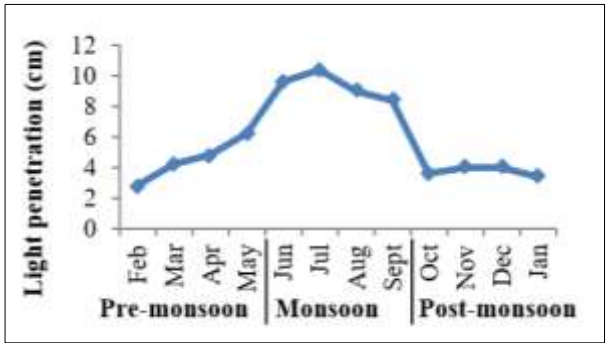

Fig 4: Monthly changes in light penetration during 2013-14 in Shirgaon estuary

Freshwater discharge and churning of bottom sediment could also be the important factors in reducing the light penetration in monsoon (Fig.4) (Table 1). Negative correlation coefficient was found between light penetration and phosphate (r = -.479) (Table 2). Similar correlation was given by (Saha *et al.*, 2001) [17].

Salinity (psu)

The salinity act as a prime factor among the most important environmental parameters in the distribution of living organisms (Chandramohan *et al.*, 1998) [5]. The salinity variation in the exchange of ions and nutrients because of the tidal flow and low duringthe monsoon season in the Shirgaon estuary. The maximum salinity was recorded in the month of January (28.7 psu) and minimum of zero salinity was recorded in the month August. The maximum salinity value observed in the post-monsoon season may be attributed to seasonal coastal upwelling in the post-monsoon season along west coast of India, while minimum salinity value approaching zero in the monsoon season which may be due to large quantity of freshwater inflow resulting in the dilution of water and hence causing reduction in salinity. It may be also due to the influx of freshwater from land run off caused by monsoon (Fig. 5) (Table 1). Negative correlation coefficient was found between salinity and atmospheric temperature (r = .407) (Table 2) Similar correlation was found by (Muthukumaravel *et al.*, 2012) [12].

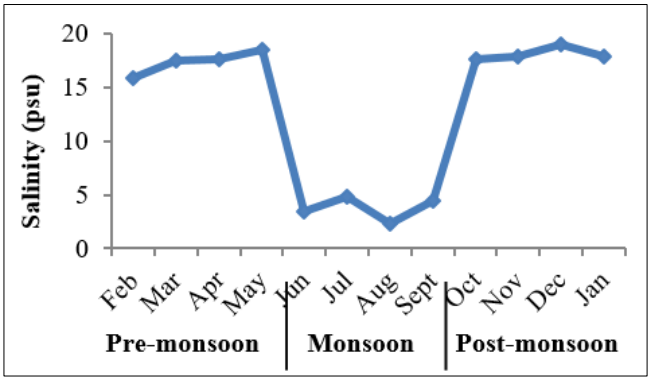

Fig 5: Monthly changes in salinity during2013-14 in Shirgaon estuary

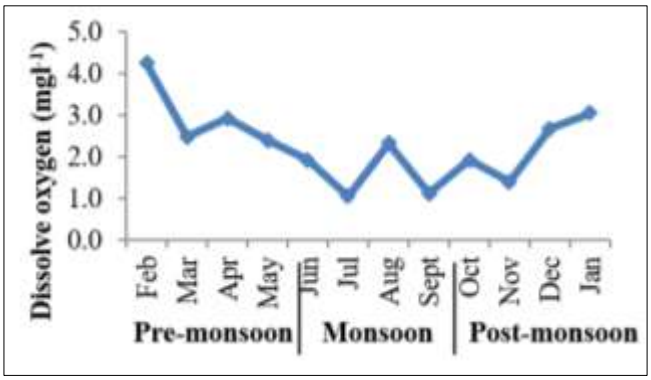

Fig 6: Monthly changes in dissolved oxygen during 2013-14 in Shirgaon estuary

Table 1: Correlation co-efficient among environmental parameters of Shirgaon estuary

		Atm Temp. (^{0}C)	Water Temp. (^{0}C)	pH	Water transparency (cm)	Salinity (psu)	Do (mgl^{-1})	Alkalinity (mgl^{-1})	Nitrate (µMgl^{-1})	Nitrite (µMgl^{-1})	Phosphate (µMgl^{-1})	Silicate (µMgl-1)
Pre-monsoon	Feb	31.48	26.2	6.46	2.8	15.9	4.24	52.6	0.000434	6.47313E-05	0.000385	0.000845
	March	29.26	26.6	6.92	4.2	17.54	2.48	32	0.000575	5.96884E-05	0.000258	0.000973
	April	32.14	31.8	6.82	4.8	17.6	2.92	56	0.000636	5.9558E-05	0.000258	0.000963
	May	29.12	31.4	6.96	6.2	18.48	2.4	32	0.000714	5.78191E-05	0.000258	0.000946
Monsoon	June	28.02	26.6	6.46	9.6	3.48	1.92	17.6	0.000562	0.000159459	0.000262	0.001038
	July	26.6	27	7.06	10.4	4.86	1.04	13.6	0.000816	0.000124289	0.000261	0.000862
	August	26.22	26.2	7.12	9	2.3	2.32	9	0.000811	8.06424E-05	0.000265	0.000811
	Sept	25.98	25.8	7.04	8.4	4.5	1.12	4.4	0.000619	8.64678E-05	0.000261	0.001124
Post-monsoon	Oct	29.04	26.6	6.5	3.6	17.6	1.92	8.8	0.00063	7.52083E-05	0.000259	0.000846
	Nov	28.86	27.4	6.06	4	17.94	1.4	10	0.000501	6.76005E-05	0.000367	0.000842
	Dec	23.78	22.4	7.18	4	18.98	2.68	9	0.00052	6.25142E-05	0.0004	0.000892
	Jan	26.48	26.8	6.8	3.4	17.9	3.04	14.8	0.000394	5.95145E-05	0.000262	0.001077

Dissolved oxygen (mgl^{-1})

Dissolved oxygen is an important constituent of water and its concentration in water is an indicator of prevailing water quality and ability of water body to support a well-balanced aquatic life. The maximum dissolved oxygen was recorded in the month of Feb (4.8 mgl^{-1}) and minimum in the month of July (0.4 mgl^{-1}).The maximum DO in late pre-monsoon period may be attributed to high intensity of pre-monsoon surface winds in the said period which may have elevated the DO level in the estuarine water. In monsoon season, because of flooding and low light penetration it may have affected the photosynthetic activity in the estuarine water, which intern reduced the dissolved oxygen level in monsoon (Fig. 6) (Table 1). Positive correlation coefficient observed between dissolved oxygen and light penetration (Hotekar *et al.*, 2011) [8]. Negative significant correlation coefficient was found between DO and pH (r = -.048) (Table 2) (Vijayakumar *et al.*, 2014) [22].

Alkalinity (mgl^{-1})

The value of alkalinity provides idea of natural salts present in water. Alkalinity of water is due to presence of mineral salt present in it. It is primarily caused by the carbonate and bicarbonate ions. The maximum alkalinity was recorded in

the month of January (80 mgl^{-1}) indicate greater ability of the river water to support algal growth and other aquatic life in this season (Khatoon *et al.*, 2013) [10] and minimum alkalinity in the month of September (3mgl^{-1}) (Fig.7) (Table 1). Total alkalinity fluctuated in accordance with the fluctuation in the pollution load Khatoon *et al.*, (2013) [10]. Negative correlation between alkalinity and light penetration(r = -.357) (Table 2) (Hotekar *et al.*, 2011) [8].

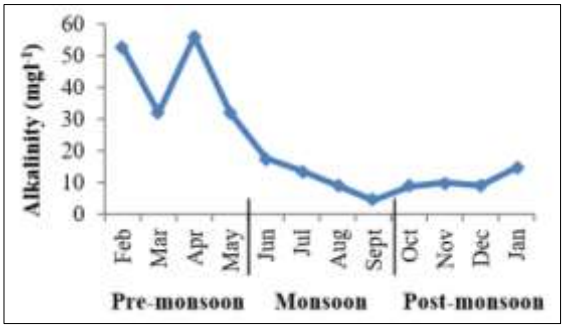

Fig 7: Monthly changes in alkalinity during 2013-14 in Shirgaon estuary

Nutrients

These studies have revealed that the high nutrient content brought about by the river run off during the monsoon season contributes significantly to the nutrient content of estuaries together with the nutrients received from sea water due to tidal effect. As such the nutrient content of estuarine area will be higher than that of both seawater and freshwater. Followed by the rainy season the nutrient influx will be lower and utilization by plankton will be higher. These factors reduce the nutrients drastically and result in the seasonal fluctuations.

Nitrate (µMl^{-1})

Nitrate content is excellent parameters to judge organic pollution and it represents the highest oxidized form of nitrogen and a vital nutrient for growth, reproduction and survival of organisms. The maximum nitrate was recorded in the month of August (0.00154 µM l^{-1}) and minimum nitrate in the month of January (0.000323 µM l^{-1}). The recorded highest nitrate value during monsoon season could be mainly due to the possibility of receiving organic materials from the catchment area during the monsoon also by fresh water inflow, mangroves leaves (litter fall) decomposition and terrestrial run-off during the monsoon season (Fig. 8) (Table 1). Similar results found by (Gowda *et al.*, 2002) [7]. Negative significant correlation coefficient was found between nitrate and salinity (r = -.538) (Table 2) (Vijayakumar *et al.*, 2014) [22].

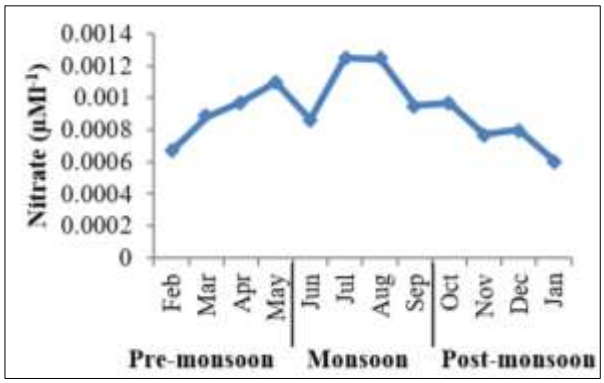

Fig 8: Monthly changes in nitrate during 2013-14 in Shirgaon estuary

Fig 9: Monthly changes in nitrite during 2013-14 in Shirgaon estuary

Table 2: Seasonal variations of environmental parameters of Shirgaon estuary

	Atm. Temp (^{0}C)	Water Temp (^{0}C).	pH	Water Transparency (cm)	Salinity (psu)	Do (mgl^{-1})	Alkalinity (mgl^{-1})	Nitrate (µMgl^{-1})	Nitrite (µMgl^{-1})	Phosphate (µMgl^{-1})	Silicate (µMgl^{-1})
Atm.temp. (^{0}C)	1										
Water temp. (^{0}C)	.841**	1									
pH	-.334	-.140	1								
Transparency (cm)	-.273	.022	.365	1							
Salinity (psu)	.407	.192	-.252	-.910**	1						
Do (mgl^{-1})	.356	.051	-.048	-.623*	.483	1					
Alkalinity (mgl^{-1})	.770**	.575	-.124	-.357	.382	.696*	1				
Nitrate (mgl^{-1})	.032	.276	.496	.717**	-.538	-.510	-.170	1			
Nitrite (mgl^{-1})	-.002	-.096	.047	-.463	.279	.189	-.083	-.156	1		
Phosphate (mgl^{-1})	-.164	-.490	-.286	-.479	.368	.358	.059	-.514	.164	1	
Silicate (mgl^{-1})	-.097	.086	.177	.141	-.127	-.113	-.052	-.301	-.053	-.428	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Nitrite (µMl^{-1})

The higher concentration of nitrite and its seasonal variation could be attributed to the variation in phytoplankton, excretion, oxidation of ammonia and reduction of nitrate. It is most unstable and perhaps important source of nutrient in autotrophic forms. The maximum nitrite was recorded in the month of July (0.000208 µMl^{-1}) during the monsoon and minimum nitrite in the month of November (0.000052 µMl^{-1}).The elevated nitrite concentration in estuary may be due to influx of terrestrial water during monsoon season (Fig. 9) (Table 1). Negative significant correlation coefficientwas found between nitrite and temperature (r = -.002) (Table 2) (Vijayakumar *et al.*, 2014) [22].

Inorganic phosphate (µMl^{-1})

The variations in phosphate concentration could be attributed

to their utilization by phytoplankton. Agriculture runoff containing phosphate fertilizers as well as the wastewater containing the detergents etc. tend to increase phosphate pollution in water. Variations may also be caused by various processes like adsorption and desorption of phosphate and buffering action of sediment under varying environmental condition. The maximum inorganic phosphate was recorded in the month of February (0.000515 µMl^{-1}) and minimum inorganic phosphate in the month of March (0.00253 µMl^{-1}).

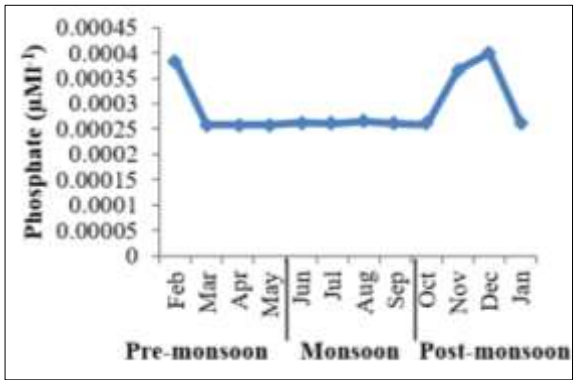

Fig 10: Monthly changes in phosphate during 2013-14 in Shirgaon estuary

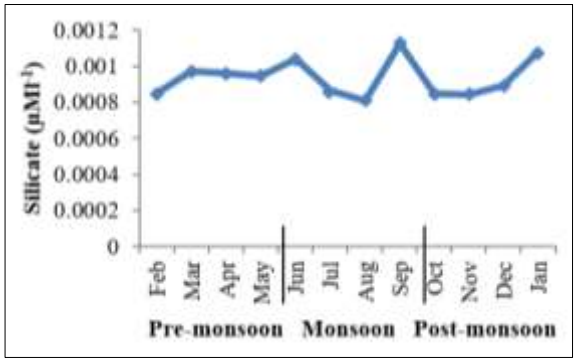

Fig 11: Monthly changes in silicate during during 2013-14 in Shirgaon estuary

The maximum inorganic phosphate was recorded during pre-monsoon season in the month of February, while minimum also during pre-monsoon season in the month of March, which may be due to higher utilization by phytoplankton population which was high during or just before the concerned period (Fig. 10) (Table 1). Inorganic phosphorus showed positive correlation with dissolved oxygen (r =.358) and negative correlation with pH (r = -.286) (Table 2) (Muthukumaravel *et al.*, 2012) [12].

Silicate (µMl^{-1})

The variation of silicate in coastal waters is influenced by physical mixing of seawater with freshwater, adsorption into sedimentary particles, chemical interaction with clay minerals, co-precipitation with humic components, and biological removal by phytoplankton, especially by diatoms and dinoflagellates., maximum silicate value (0.00129 µMl^{-1}) observed in the monsoon season could be due to heavy influx of freshwater derived from land drainage carrying silicate, leached out from the terrestrial origin and also from bottom sediments that exchange nutrients with overlying water due to the turbulent nature of water. The minimum silicate value (0.000503 µMl^{-1}) in the post-monsoon season may be due to its utilization by increased population of diatoms as diatoms essentially require silicate for their cell wall or frustule formation (Newell and Newell, 1977) [14] (Fig. 11) (Table 1). Negative significant correlation coefficient was found between silicate and salinity(r = -.127) (Table 2) (Vijayakumar *et al.*, 2014) [22].

Conclusion

The results of present study determine water quality of Shirgaon estuary and adjacent mangrove habitat of Shirgaon, Ratnagiri coast. Water quality is an important part of environment. Physico-chemical characteristics of surface water varied according to seasons. The factors, discharging of domestic sewage, oil discharge from fishing boat, mangrove cutting, and acquiring coastal habitat for construction of roads is responsible to manipulate the environment quality and lifestyle of the living species. The results revealed that, Shirgaon estuary is productive in nature for aquatic flora and fauna.

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References

1. AOAC. Official Methods of Analysis, 18th ed. Association of Official Analytical Chemist, Washington, D.C. 1094, 2006.
2. APHA. Standard Methods for the Examination of Water and Waste Water 21sted. American Public Health of Association, American Water Works Association Environmental Federation, Washington DC, USA. 2605, 2005.
3. Ashok Prabu V. Seasonal variations in Physico-chemical characterisitcs of Pichavaram mangroves, South east coast of India. J Environ. Biol 2008;29(6):945-950.
4. Bhaware B, Rodriguez MA, Kurhe A. Study of seasonal variations in physico-chemical parameters and nutrients in water of Bhatye estuary, Ratnagiri central, west coast of India. International Journal of Environmental Sciences 2013, 3(5).
5. Chandramohan P, Srinivasan N. Diel variations in zooplankton populations in mangrove ecosystem at Gaderu canal, Southeast coast of India. Indian J Mar, Sci 1998;27:486-488.
6. Ganapati PN. Estuarine pollution. Bull. Dept. Mar. Sci., Univ. Cochin: VI, 1975, I:1-9.
7. Gowda G, Gupta TRC, Rajesh KM, Gowda H, Lingadhal C, Ramesh AM. Distribution of phytoplankton pigments in the Nethravathi estuary. Indian Journal of Fisheries 2002;49(3):267-273.
8. Hotekar SP. Water quality in relation to plankton composition of Bhagwati Bandar, Ratnagiri. M.F. Sc. Thesis, Balasaheb Sawant, konkan Krishi Vidyapith, Dapoli, Ratnagiri 2011.
9. Karuppasamy PK, Perumal P. Biodiversity of zooplankton at Pichavaram mangroves, South India. Ad. Biosci 2000;19:23-32.
10. Khatoon N, Masihur R, Khan AH. Study of seasonal variation in the water quality among different ghats of river Ganga, Kanpur, India. J Environ. Res. Develop. Journal 2013, 8(1).
11. Kumary KSA, Azis PKA, Natarajan P. Water quality of the Adimalathuraestuary, southwest coast of India.

Journal of Marine Biology Assessment India 2007;49(1):1-6.
12. Muthukumaravel K, Vasanthi N, Sivakami R, Kandasami D, Sukumaran N. Physico-chemical characteristics of Arasalar estuary Karaikal southeast coast of India. International Journal of Institutional Pharmacy and Life Sciences 2012, 2(3).
13. Nedumaran T, Perumal P. Physico-chemical characteristic features of the Uppanar estuary, south east coast of India. J Ecotoxical. Environ. Monit 2011;21(1):1-11.
14. Newell GE, Newell RC. Marine Plankton a practical guide. Hutchinson, London, presented by Britain, 1977, 1-244.
15. Rajesegar M. Physico-chemical characteristics of the Vellar estuary in relation to shrimp farming. J Environ Biol 2003;24:95-101.
16. Ravaniah G, GeorgeenaKumari P, Narasimha Murthy CV. Water quality analysis of the Pennar estuary, Nellore. J Curr. Sci 2010;15(2):321-334.
17. Saha SB, Bhattacharyya SB, Choudhury A. Photosynthetic activity in relation to hydrobiological characteristics of a brackishwater tidal ecosystem of Sundarbansinwest Bengal, India, International Society for Tropical Ecology 2001;42(1):111-115.
18. Santhanam R, Ramanathan N, Venkataramanujam C Jagatheesan G. Phytoplankton of the Indian seas. Daya publishing house, Delhi (India) 1987, 1-280.
19. Strickland JDH, Parsons TR. A Practical Handbook of Seawater Analysis. Bull. Fish. Res. Bd. Can 1972, 167-310.
20. Vengadesh Perumal N, Rajkumar M, Perumal P, Thillai Rajkumar K. Seasonal variations if plankton diversity in Kaduviyar estuary, Nagapattinam, southeast coast of India. J Environ. Biol 2009;30(6):1035-1046.
21. Vijayakumar S, Rajan KM, Mridula R, Hariharan M. Season distribution and behaviour of nutrients with reference to tidal rhythm in the Mulkiestuary south east coast of India. J Mar. Biol. Ass. India 2000;42(1&2):21-23.
22. Vijayakumar N, Shanmugavel G, Sakkthivel D, Anandan V. Seasonal variations in physico-chemical characteristics of Thengaithittu estuary, Puducherry, South East-coast of India. Advances in Applied Science Research 2014;5(5):39-49.