

Seasonal Variations in Physico-Chemical Characteristics of Kanyakumari Coastal Waters, South West Coast of India

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Abstract

Physico-chemical parameters of coastal waters were determined along the Kanayakumari coast, in the southwest coast of India. All the physico chemical parameters such as atmospheric temperature, surface water temperature, pH, salinity, dissolved oxygen content and nutrient like nitrate, silicate, phosphate were studied for a period from July 2018 to May 2019. Atmospheric and surface water temperature varied from 24.7-33.7°C and 23.5-33.9°C. Hydrogen ion concentration ranged between 7.61 to 8.61. It was alkaline throughout the study period. Salinity varied from 29.7ppt to 38.1ppt. Variation in dissolved oxygen content was from 3.67-5.63 mg/L. Concentrations of nutrients viz. nitrate (10.4 – 55.01 mg/L), silicate (8.9- 13.7 µg/L), phosphate (0.05- 1.04 mg/L) and also varied independently.

Keyword: *Physico-chemical parameters, Nutrients, South west coast, Kanyakumari.*

INTRODUCTION

Hydro biological studies are the important one associated with flora and fauna of the marine and estuarine environment. Physicochemical properties of the marine environment will play a dynamic role in determining the type of ecosystems [45]. Changes in the physicochemical parameters provide valuable information on the quality of water [5], the sources of their differences and their effects on the functions and biodiversity of the water body [13]. Estuarine and coastal areas are complex and dynamic aquatic environment [2]. The marine environment, as a complex system is

mainly influenced by various physical, chemical and biological processes. The open ocean is more stable compared to the near shore waters, where the interaction with the terrestrial zone is more effective in bringing about variations in different physico-chemical parameters. Hence a thorough knowledge of hydrography is indispensable to estimate the quality of the environment and its influence on biological fertility [28]. Coastal marine environments are reported to have greater biodiversity than open ocean regions and majority of world's most productive marine ecosystems are found within coastal

environment and owe their productivity, diversity and wealth of life to their terrestrial adjacency [7]. Coastal water has become a major concern because of its values for socioeconomic development and human health. With the growth of human populations and commercial industries, marine water has received large amounts of pollution from a spread of sources such as recreation, fish culture, bathroom flushing and the assimilation and transport of pollution effluents [49].

The aquatic ecosystems are affected by some health stressors that extensively deplete biodiversity, the loss of biodiversity and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems [35]. To review the potentialities of any aquatic system, hydrobiological studies are very essential. Physico-chemical parameters are responsible for the spatio-temporal variations of all aquatic organisms. The investigations on meteorological and hydrographical features are necessary for assessing the fertility and productivity of any ecosystem [31]. Coastal waters are one of the nation's most important natural resources, valued for their ecological richness as well as for the many human activities they support [23]. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, Dissolved Oxygen and carbondioxide. Others are total suspended and dissolved solids, total alkalinity and acidity and heavy metal contaminants. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna) [22]. The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physico-chemical parameters and biological characteristics. So, monitoring of these parameters is essential to identify the

magnitude and source of any pollution load [46]. So the present study undertaken to find out the physiochemical parameters of seawater in the study area.

Materials and Methods

Description of the Study Area

Kanyakumari is a coastal town in the state of Tamil Nadu on India's southern tip. It is a most popular tourist place in Tamil Nadu. Kanyakumari coast is a rocky area. The rocky areas are exposed to tide and these rocks are covered by macroalgae. The selected study area includes five stations of Kanyakumari coasts namely Kurumpanai, Manavalakurichi, Muttom, Kovalam and Leepuram.

Period of Study

The study was conducted for a period of twelve months from July 2018 to June 2019 at the five stations namely Kurumpani, Manavalakurichi, Muttom, Kovalam and Leepuram of Kanyakumari District, Tamil Nadu. Depending on the climatic conditions prevailing in the study area, the period was divided into four seasons viz: Southwest monsoon (July to September 2018), Northeast monsoon (October to December 2018), Postmonsoon (January and February 2019), and Premonsoon (March to May 2019).

Physico-Chemical Parameters

Comparative study on the Physico-chemical Parameters in the five stations of south west coast of India namely Kurumpani, Manavalakurichi, Muttom, Kovalam and Leepuram were carried out from July 2018 to June 2019. The atmospheric and surface water temperatures were measured using a mercury centigrade thermometer. The hydrogen ion concentration was determined on the spot itself with BDH indicator papers and the same was

compared with the portable pen pH meter. The salinity of water is determined by titration with silver nitrate [8]. The classical method for the determination of dissolved oxygen in aqueous solutions is known as the Winkler method described by [43]. The nutrient such as nitrate, phosphate, silicate were determined following the methods of [12].

Data Analysis

The hydrological data were analysed statistically through to Standard Deviation and Two way ANOVA analysis.

Results

Physico- Chemical parameters Atmospheric Temperature

Table (1 to 8) shows the physico chemical data obtained from the five stations. Atmospheric temperature ranged from 24.7°C to 33.7°C during the study period (Table-1) and a minimum of 24.7°C was recorded during South west monsoon at station I (Kurumpanai) and maximum 33.7°C during pre-monsoon at station V (Leepuram).

Table 1 Seasonal Variation in Atmospheric Temperature (0°C) Recorded During July 2018 to May 2019

Seasons	Atmospheric Temperature (0°C)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-westmonsoon	24.7±0.8	26.5±0.2	26.4±0.13	28.5±0.3	28.4±0.3
North-eastmonsoon	25.8±0.13	27.4±0.1	29.3±0.3	30.3±0.09	30.1±0.5
Post-monsoon	25.5±0.5	25.7±0.6	28.1±0.12	28.0±0.3	28.3±0.4
Pre-monsoon	27.8±0.15	29.7±0.3	30.8±0.09	30.6±0.5	33.7±0.1

Surface Water Temperature

Surface water temperature ranged from 23.5° to 33.9°C during the study period (Table 2) with a

minimum value of 23.5°C was observed during south west monsoon at station I and maximum value 33.9°C was observed during pre-monsoon at station V.

Table 2 Seasonal Variation in Surface Water Temperature (0°C) Recorded During July 2018 to May 2019

Seasons	Surface water Temperature (0°C)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-westmonsoon	23.5±0.1	25.7±0.4	25.4±0.2	26.5±0.1	26.3±0.3
North-eastmonsoon	30.3±0.9	30.3±0.5	30.5±0.05	29.3±0.3	29.6±0.2
Post-monsoon	28.1±0.2	28.2±0.09	29.7±0.8	29.6±0.2	30.8±0.6

Pre-monsoon	26.8±0.1	28.6±0.3	29.8±0.07	28.4±0.4	33.9±0.1
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pH

The pH value varied from 7.61 to 8.61 (Table 3) with minimum pH of 7.61 was recorded in

south west monsoon season at station III (Muttom) and maximum 8.6 was recorded during pre monsoon at station V (Leepuram).

Table 3 Seasonal Variation of pH of Seawater in the Study Areas During July 2018 to May 2019

Seasons	pH				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-westmonsoon	7.61±0.02	7.93±0.02	7.97±0.05	7.9±0.23	7.7±0.24
North-east monsoon	7.96±0.23	8.03±0.17	7.5±0.15	8.08±0.14	7.98±0.05
Post-monsoon	8.38±0.01	8.37±0.01	8.33±0.06	8.35±0.02	8.57±0.01
Pre-monsoon	8.39±0.02	8.49±0.01	8.50±0.02	8.45±0.02	8.61±0.2

Salinity

Salinity value ranged from 29.7ppt to 38.1ppt (Table 4).The maximum value of 38.1ppt

salinity was recorded in pre monsoon season at station V (Leepuram) and minimum 29.7ppt in south west monsoon at station III (Muttom).

Table 4 Seasonal Variation of Salinity (ppt) of Seawater in the Study Areas During July 2018 to May 2019

Seasons	Salinity (ppt)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-west monsoon	33.7±0.77	32.9±0.72	29.7±0.58	32.6±0.05	34.7±0.3
North-east monsoon	32.47±0.19	32.4±0.07	31.73±0.71	30.41±0.01	32.38±0.43
Post- monsoon	35.45±0.03	32.4±0.17	34.38±0.01	32.4±0.07	33.75±0.02
Pre-monsoon	36.45±0.02	34.47±0.02	34.4±0.36	32.4±0.07	38.1±0.34

Dissolved oxygen

Dissolved oxygen concentration varied between 3.67mg/l and 5.63mg/l (Table 5).The

maximum value 5.63mg/l was recorded in post monsoon at station III (Muttom)and the minimum 3.67mg/l was recorded in South and

North east monsoon at station II
(Manavalakurichi).

Table 5 Seasonal Variation in the Dissolved Oxygen Content (mg/L) of Seawater in the Study Areas during July 2018 to May 2019

Seasons	Dissolved Oxygen (DO) mg/L				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-west monsoon	4.09±0.19	3.67±0.06	4.41±0.20	3.70±0.10	4.16±0.29
North-east monsoon	4.31±0.02	3.67±0.07	5.39±0.05	3.94±0.04	4.92±0.07
Post-monsoon	4.87±0.04	4.08±0.01	5.63±0.03	3.98±0.02	5.08±0.02
Pre-monsoon	4.85±0.03	4.06±0.03	5.60±0.02	3.97±0.02	5.07±0.02

NUTRIENTS

Nitrate

The nitrate value of present study was varied from 10.4mg/l to 55.01mg/l (Table 6) in the

selected coasts of Kanyakumari district. The maximum content of nitrate 55mg/l was recorded in north east monsoon at station I (Kurumpanai) and the minimum nitrate content 10.4mg/l was recorded in pre monsoon at station V (Leepuram).

Table 6 Seasonal Variation in the Nitrate Content (mg/L) of Seawater in the Study Areas during July 2018 to May 2019

Seasons	Nitrate (mg/L)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-west monsoon	40±0.25	34.5± 0.3	35.7±0.15	35.5±0.11	30.5±0.5
North-east monsoon	55.01±0.09	20.2±0.15	25.3±0.15	20.1±0.5	35.2±0.3
Post-monsoon	35.02±0.4	20±0.20	20.5±0.35	25.06±0.9	25.1±0.65
Pre-monsoon	20.4± 0.25	15.03±0.7	19.4±0.1	19.2±0.1	10.4±0.17

Silicate

The silicate content was varied from 8.9-13.7µg/l (Table 7) in the selected coast at different seasons. The maximum value

13.7µg/l was observed in south west monsoon at station I (Kurumpanai) and minimum 8.9µg/l in post monsoon at station III (Muttom).

Table 7 Seasonal variation in the Silicate Content (micromole/L) of seawater in the Study Areas during July 2018 to May 2019

Seasons	Silicate (micromole/L)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-west monsoon	13.7±0.60	10.85±0.45	9.05±0.45	10.10±0.29	13±0.20
North-east monsoon	12.7±0.20	9.6±0.3	9.1±0.17	10.1±0.2	12.8±0.1
Post-monsoon	10.5±0.2	10.1±0.03	8.9±0.13	9.7±0.08	11.2±0.2
Pre-monsoon	11.2±0.2	10.4±0.3	9.1±0.17	10.9±0.3	11.5±0.4

Phosphate

In the present study the phosphate content was varied from 0.05mg/l to 1.04mg/l (Table 8) in the selected coast at different seasons. The maximum phosphate content 1.04mg/l was

observed in postmonsoon and premonsoon seasons at station II (Manavalakurichi) and minimum value 0.05mg/l was observed in north east monsoon at station II (Manavalakurichi).

Table 8 Seasonal Variation in the Phosphate Content (mg/L) of Seawater in the Study Areas during July 2018 to May 2019

Seasons	Phosphate (mg/L)				
	Kurumpanai	Manavalakurichi	Muttom	Kovalam	Leepuram
South-westmonsoon	0.45±0.04	0.34±0.04	0.45±0.05	0.19±0.01	0.44±0.06
North-eastmonsoon	0.2±0.1	0.05±0.01	0.1±0.03	0.5±0.17	0.1±0..02
Post-monsoon	0.2±0.11	1.04±0.02	0.3±0.13	0.5±0.2	0.15±0.01
Pre-monsoon	0.10±0.05	1.04±0.01	0.06±0.02	0.20±0.04	0.10±0.06

ANOVA Analysis

Twoway ANOVA analysis for physico-chemical parameters

Twoway Anova analysis for physico chemical parameters viz., atmospheric and surface water temperature, pH, salinity, dissolved oxygen content, and nutrient content such as nitrate, phosphate and silicate showed different results.

No significant difference in the atmosphere temperature between seasons and stations was observed however this parameters showed significant difference in north east monsoon season. Surface water temperature showed significant difference in North east monsoon and post monsoon season between the stations studied. But southwest monsoon and pre monsoon showed significant difference in the

surface water temperature. No significant difference in the pH value between stations and seasons. But salinity showed significant difference between stations and seasons. Dissolved oxygen showed significant difference between stations but insignificant difference between seasons. Nutrients like phosphate and nitrate showed significant difference between stations in premonsoon season. But silicate showed insignificant differences.

Comparative Analysis of Physico-Chemical Parameters among the Five Coasts under study

Most of the physico chemical parameters such as atmospheric and surface water temperatures, pH and salinity were high in Leepuram coast during premonsoon season except, dissolved oxygen levels in Muttom during post monsoon. But in Kurumpanai coast, the atmospheric and surface water temperatures were low during South west monsoon. The pH and salinity were low in Muttom coast during South west & North east monsoon. The DO content was low in Manavalakurichi coast during North and South west monsoon. Contrary to that the nutrient content such as nitrate and silicate were high in Kurumpanai coast during north east and south east monsoon and low in Leepuram and Muttom coast during pre and post monsoon. The low and high value of phosphate content was noted in Manavalakurichi coast during North east and pre monsoon season.

DISCUSSION

Physico Chemical Parameters

Physico chemical parameters such as temperature, salinity, water current tidal ranges, nutritional availability etc. are determining the species diversity and abundance of macroalgae in the particular area. Last few years, information on the physico

chemical parameters in the coastal areas of Kanyakumari District is lacking. So in the present study, select 5 coasts in Kanyakumari district and analyse the physico chemical parameters of coastal water.

Temperature

Temperature is basically important for its effects on the chemistry and biological activities of organisms in water. The variation in the water temperature was due to some factors like intensity of solar radiation, tidal currents, fresh water influx, incidence of upwelling waters and atmospheric variations [15]. In the present study, high atmospheric temperature was recorded during premonsoon season where as low during south west monsoon. The increase in water temperature during the Pre-monsoon period could be attributed to high solar radiation [15,29]. The low temperature in the monsoon season was due to the overcast sky and heavy rainfall [21]. Similar results were reported by [17, 1]. Surface water temperature was maximum (33.9°C) during premonsoon and minimum (23.5°C) during south west monsoon. These findings are correlated with [6,18].

pH (Hydrogen ion concentration)

Hydrogen ion concentration or pH is one of the vital environmental characteristics decides the survival, metabolism, physiology and growth of aquatic organisms. pH is influenced by acidity of the bottom sediment and biological activities [4]. pH may be affected by total alkalinity and acidity, run off water from surrounding rocks and water discharges [48]. The water in the study area was alkaline throughout the study period. The high pH during the pre- monsoon may be due to the uptake of CO₂ by photosynthesizing organisms and high biological activity [4, 42]. The low pH observed during the monsoon season may be

due to the dilution of seawater by freshwater influx, low primary productivity, reduction of salinity, low temperature and organic matter decomposition [31]. Similar results were reported by [17,1, 44].

Salinity

The salinity acts as a limiting factor in the distribution of living organisms and its variation caused by dilution and evaporation is most likely to influence the fauna in the intertidal zone [14]. Salinity is regarded as the second important physical characteristic of the marine environment [37]. It varies in different ecosystems according to topography, tides and freshwater inflow [40]. In the present study, lower salinity (29.7ppt) values was recorded during the south west monsoon season, which may be due to the dilution of coastal water by the addition of freshwater from the reversing sources [20], whereas higher value (38.1ppt) was recorded during the pre-monsoon season, which could be attributed to low rainfall, decreased fresh water inflow, high temperature and evaporation [20,32,35]. It was similar to the results of [17,25,1,44].

Dissolved Oxygen

The dissolved oxygen is essential to the aquatic organisms and is greatly affected by their metabolism [47]. Seasonal variation in the dissolved oxygen content was due to the freshwater flow and terrigenous impact of sediments [32]. The high values of dissolved oxygen (5.63mg/l) observed during post monsoon season could be attributed by the input of dissolved oxygen -rich freshwater confirmed by [31].

Nutrients in the sea water Nitrate

Nitrate is one of the great indicators of pollution of water which shows the topmost oxidised form of nitrogen. Its play a vital role

in strengthening the aquatic life in coastal ecosystem. The high nitrate content (55.01mg/l) during north east monsoon season was due to fresh water inflow to leaching of rocks, fertilizer, chemical industries, domestic and municipal sewage, organic matter decomposition and terrestrial run-off during the monsoon season [3, 30]. The low value (10.4mg/l) of Pre monsoon was due to the utilization by phytoplankton as evidenced by high photosynthetic activity and the dominance of neurotic seawater having a negligible amount of nitrate [9]. The results were coincided with the findings of [16,25].

Silicate

Silicate is one of the important nutrients which regulate the phytoplankton distribution in the coastal water. The variation of silicate in coastal water is influenced by physical mixing of seawater with freshwater, adsorption into sedimentary particles, chemical interaction with clay minerals, co-precipitation with humid components, and biological removal by phytoplankton, especially by diatoms and silica flagellates [41]. In the present study, the maximum silicate content (13.7mg/l) during south west monsoon was due to the significant flow of monsoonal fresh water derived from land drainage carrying silicate leached out from rocks and sediment have been exchanged with superimposed water within the coastal

environment [15]. The low value of silicate (8.92mg/l) recorded during Post-monsoonal season could be attributed to uptake of silicates by phytoplankton for their biological activity [38]. Similar result were reported by [16,20,25,44].

Phosphate

The dissolved inorganic phosphate is an important nutrient for marine phytoplankton,

marine biota actively involved in the activities [25]. In the present study maximum phosphate content was observed during post and pre monsoon season and minimum during north east monsoon. It was due to the mixing of phosphate concentration in the fresh water with the sea water within the sea land interaction zones upwelling and microbial decomposition of organic matters [27,41]. Similar findings were observed by [15,38,44].

Relationship between physico-chemical parameters and macroalgal diversity

In the present study maximum number of macroalgal species available during southwest monsoon and followed by North east monsoon and minimum in post and pre monsoon. Similar findings was observed by [34]. They reported that maximum number of macroalgae was observed in southwest monsoon (30 genus), followed by North east monsoon (20 genus) and more or less equal number of macroalgae distributed in summer and winter seasons. More number of macroalgae observed during monsoon season was due to low temperature, low salinity, low desiccation and increased nutrient concentrations in ambient waters [10]. Similar finding was observed by [18]. Low seaweed population in summer might be due to high temperature, low nutrient level and sand fluctuations at the area [26]. The present study reported, a total of 35 species of macroalgae from Muttom, 30 species from Kovalam and less number of macroalgal species i.e. 15, 10, 7 found in Leepuram, Manavalakurichi and Kurumpanai respectively. Similar findings were reported by [18] in her thesis. The maximum number of seaweed observed at Muttom coastal waters may be due to the presence of intertidal rocky reefs reported by [11]. The red algae dominated in all the stations except Kurumpanai (station-1). Similar finding was observed by [33], who studied the

distribution and diversity of marine macroalgae at four southern districts of Tamil nadu. It indicates that the presence of the rocky coasts is essential for the attachment of macroalgae. The above findings also confirmed by the studies of [19]. The macroalgae species viz; *Ulva fasciata* of Chlorophyceae, *Sargassum wightii* of Phaeophyceae, *Gracilaria corticata* of Rhodophyceae were dominant throughout this study period. It was similar to the findings by [39]. Reviews on the seasonal studies of marine macroalgae along the East and West coast of India and other islands were found that *Caulerpa scalpelliformis*, *Caulerpa veravalensis*, *Caulerpa crassa* and *Sargassum wightii* were recorded throughout the year in Tamil Nadu [33].

Conclusion

The present study attempted to record the seasonal variation of hydrographical parameters along the southwest coast of India. The parameters like atmospheric temperature, surface water temperature, pH, salinity and phosphate increased premonsoon season was observed. In contrast, an increase in nitrate, silicate during north east and south west monsoon season. Dissolved oxygen content was increased post monsoon. Kanyakumari coastal water is subjected to seasonal fluctuations in physico chemical parameters depending upon the seasonal tidal amplitude and freshwater influx resulting in a continuous exchange of organic, inorganic, plant and animal matters. The knowledge of nutrients, related to their sources, availability and the utilization levels gives us the information about the productivity potential and health of the marine ecosystem. For future ecological monitoring and assessment along the coastal waters, the current baseline data will be helpful.

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REFERENCES

- Ajithamol, A, Shajithamol, A, Venkatesh, B, Michael Babu, M, Saraswathi, S & Bipin K jha 2014, 'phytoplankton Density in comparison with monthly variation of Hydrobiological parameters in Manakudy Estuary, South West Coast of India,' *Int. Res. J. Environment Sc*, vol.3, pp.24-31.
- Anitha, G & Sugirtha P Kumar 2013, 'Physicochemical characteristics of water and sediment in thengapattanam estuary southwest coastal zone, Tamilnadu, India,' *International Journal of Environmental Sciences*, vol. 4, no. 3, pp. 205-220.
- Ashok Prabu, V, Perumal, P & Rajkumar, M 2005, 'Diversity of microzooplankton in parangipettai coastal waters, southeast coast of India,' *J.Mar.Bol.Ass.India*, vol.47, pp.14-19.
- Balasubramanian, R & Kannan, L 2005, 'Physico chemical characteristics of the coral reef environs of the gulf of mannar biosphere reserve, India,' *Int. J. Ecol. Environ. Sci*, v. 31, pp. 265-271.
- Bat, L & Gokkurt Baki, O 2014, 'Seasonal variations of sediment and water quality correlated to land-based pollution sources in the middle of the black sea coast, Turkey,' *International Journal of Marine Science*, vol. 4, no. 12.
- Beardall, J, Beer, S & Raven, JA 1998, 'Biodiversity of marine plants in an era of climate changes: some predictions based on physiological performance,' *Botanica Marina*, pp. 113-123.
- Bierman, P, Lewis, B, Ostendorf & Tanner, J 2009, 'A Review of methods for analyzing spatial and temporal patterns in coastal water quality,' *Ecological Indicators*, doi:10.1016/j.ecolind.2009.11.001.
- Boyle, R 1693, 'An account of the honourable Robert Boyles way of examining waters as to freshness and saltness,' *Phil. Trans. Roy. Soc. Lond*, vol. 17, pp. 627-641.
- Bragadeeswaran, S, Rajasegar, M, Srinivasan, M & Kanagarajan, U 2007, 'Sediment texture and nutrients of Arasalarestuary, Karaikkal, southeast coast of India,' *J. Environ. Biol*, vol.28, pp.237-248.
- Daly, MA & Mathieson, AC 1997, 'The effects of sand movement on intertidal seaweeds and selected invertebrates at Bound Rock,' *New Hampshire USA. Mar. Biol*, vol.43, pp.45-55.
- Domettila, C, Hanniffy, Brintha, TS, Sukumaran, S & Jeeva, S 2013, 'Diversity and distribution of seaweeds in the Muttom coastal waters, south-west coast of India,' *Biodivers. J*, vol.4, pp.105-110.
- Douglas A Skoog & Donald M West, Holt, Rinehart & Winston 1976, 'Fundamentals of Analytical Chemistry,' 3rd Ed.
- Elahi, N, Ahmed, Q, Bat, L & Yousuf, F 2015, 'Physicochemical parameters and seasonal variation of coastal water from Balochistan coast, Pakistan,' *Journal of Coastal Life Medicine*, vol. 3, no. 3, pp. 199-203.
- Gibson, RN, 1982, Recent studies on the

- biology of intertidal fishes, Oceanogr.Mar.Biol.Ann.Rev, Vol.20, pp.363-414.
- Govindasamy, CL, Kannan & JayapaulAzariah, 2000, Seasonal variation in physico- chemical properties and primary production in the coastal water biotopes of Coromandel coast, India.J.Environ.Biol, Vol.21, pp.1-7.
- James Balgan Anand, D & Mary Jelastin Kala,S,2015, Study on hydrographic properties in the coastal waters along South East Coast of India,AJER, Vol.4, no.6, pp .203-214.
- James Balgan Anand,D,Mary Jelastin Kala,S &Vijaya Kumar,P,2015,Monthly variations of water quality along South East Coast of India,In.J.of Geology,Ag.andEnviron.sci, Vol.3, no.3,pp.10-15.
- Jhoncy Christobel, G, 2012, Studies on bioactivity and bioadsorption pattern of chosen macroalgal extracts with special emphasis on their influence on the growth and metabolism of microalgae used as live feed in aquaculture, Ph.D. Thesis, University of Kerala.
- John Peter Paul, J & Raja, P, 2011, Studies on the distribution of seaweed resources in Kanyakumari region,the south east coast of Tamil Nadu, J.Basic App.Biol, Vol.5, no.1&2, pp.246-251.
- Kamalkanth, S, Muniyan, M & Christyponni, A, 2012, Seasonal variations in physico chemical parameters at tranquebar coastal nagapattinam Tamilnadu, India, Int. J. Environ. Biol, vol. 2, pp. 203-207.
- Kannan, R & Kannan, L, 1996, Physicochemical characteristics of seaweed beds of the palkbay, South East coast of India, Indian J.Mar.Sci, Vol.25, pp.358-362.
- Lawson, EO, 2011, Physico-chemical parameters and heavy metal contents of water from the Mangrove swamps of lagos lagoon, lagos, Nigeria, Advances in Biological Research, vol. 5, no. 1, pp. 8-21.
- Mack, JJ & Micacchion,M, 2006, 'An ecological assessment of ohio mitigation banks: vegetation, amphibians, hydrology and soils.' Ohio EPA Technical Report WET/2006-1. Columbus, OH: 2006: Ohio Environmental Protection Agency.
- Mackey, MRK, Labiosa, GR, Street, H, Past, J & Paytan, A 2007, Phosphorus availability, phytoplankton community dynamics and taxon-specific phosphorus status in the gulf of aqaba, red sea, limnol, Oceanogra, vol. 52, pp. 873-885.
- Meena, R & Chandrakala, N, 2017,Physico-chemical variations in bay of bengal coastal waters,south east coast of India,IRJET, Vol.4, no.06, pp.1506-1515.
- Nair, NB, Sobha, V, Chandran, R, Rathiammal, M, Maya S & Suryanarayanan, H, 1990, Algal resources of Kerala coast-Occurance and relative abundance of Phaeophyta along southwest coast of India, Proceedings of the Seminar on Phaeophyceae in India, June 4-7, Madras,India.
- Paytan, A, Mclaughlin, K, 2007, The oceanic phosphorous cycle, Chem.Rev, Vol.107, pp.563-576.
- Poonam, B & Rahul, K 2012, Status of seawater quality at few industrially important coasts of Gujarat (India) off Arabian sea, Indian Journal of Geo-Marine Sciences, vol. 41, no. 1, pp. 90-97.

- Puthiya, SC, Poongothai, S & Neelakantan, MA, 2009, Impact of industrial pollution on the physico-chemical characteristics of sea water in thoothukudi coastal area, *Rasayan J. Chem*, vol. 2, pp. 912-919.
- Rajaram, R, Srinivasan, M & Rajasegar, M, 2005, Seasonal distribution of physico-chemical parameters in effluent discharge area of Uppanar estuary, Cuddalore, Southeast coast of India, *J. Environ. Biol*, Vol.26, pp.291-297.
- Rajasegar, M, 2003, Physico-chemical characteristics of the velar estuary in relation to shrimp farming, *Journal of Environ Biol*, vol. 24, pp. 95-101.
- Rajkumar, M, Perumal, P, Ashok Prabhu, V, 2009, Diversity of phytoplankton in Pichavaram mangrove waters, southeast coast of India, *Journal of Environmental Biology*, Vol.30, pp.489-498.
- Sahayaraj, K, Rajesh, S, Asha, A, Rathi, JM & Patric, R, 2014, Distribution and diversity assessment of the marine macroalgae at four southern districts of Tamil Nadu, India, *Ind. J. Geo-Mar. Sci*, Vol.43, pp.607-617.
- Sahayaraj, K & Jagvir Singh, 2016, Seasonal changes on the diversity and abundance of intertidal macro algae at four southern districts of Tamil Nadu, India, *Ecologia*, Vol.6, no.1-3, pp.13-18.
- Sahu, G, Satpathy, KK, Mohanty, AK & Sarkar, SK, 2012, Variations in community structure of phytoplankton in relation to phytochemical properties of coastal waters, southeast coast of India, *Indian journal of Marine Sciences*, Vol.41, pp.223- 241.
- Sala, OE, Chapin, FS, Armesto, JJ, Berlow, E, Bloomfield, J, Dirzo, R, Huber-Sanwald, E, Huenneke, LF, Jackson, RB, Kinzig, A, Leemans, R, Lodge, DM, Mooney, HA, Oesterheld, M, Poff, NL, Sykes, MT, Walker, BH, Walker, M & Wall, DH 2000, Global biodiversity scenarios for the years 2100. *Science* 287: pp. 1770- 1774.
- Sampath Kumar, P & Kannan, L, 1998, Seasonal variations in physico-chemical characteristics in the Tranquebar Nagapattinam region, southeast coast of India, *Poll. Res*, Vol.17, pp.397-402.
- Saravanakumar, A, Rajkumar, M, Serebiah, JS, Thivakaran, GA, 2008, Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat, *Journal Environmental Biology*, Vol.29, pp.725-732.
- Satheesh Sathianeson, & Wesley, SG, 2012, Diversity and distribution of seaweeds in the Kudankulam coastal waters, South-Eastern coast of India, *Biodivers. J*, Vol.3, pp.79-84.
- Satheeshkumar, P & Anisa Khan, B, 2009, Seasonal variation in physico-chemical parameters of water and sediment characteristics of Pondicherry mangrove, *African Journal of Basic & Applied Sciences*, vol. 1, no. 1-2, pp. 36-43.
- Satpathy, KK, Mohanty, AK & Natesan, U, 2010, Seasonal variation in physicochemical properties of coastal waters of Kalpakkam, east coast of India with special emphasis on nutrients, *Environ Monit Assess*, Vol.164, pp.153-171.
- Sridhar, R, Thangaradjou, T, Kumar, SS & Kannan, L, 2006, Water quality and phytoplankton characteristics in the Palk Bay, southeast coast of India, *Journal of Environmental Biology*, Vol.27, pp.19-23.

- Strickland, JDH & Parsons, TR, 1972, A practical handbook of seawater analysis, Bull Fish Res Bd Canada, Vol.167, pp.311-312.
- Sushanth Vishwanath Rai & Madaiah Rajashekhar, 2014, Seasonal assessment of hydrographic variables and phytoplankton community in the Arabian sea waters of kerala, southwest coast of India, Brazilian Journal of Oceanography, vol. 62, no. 4, pp. 279-289.
- Thakur Bignesh, B, Chavda, C & Salvi, H 2014, Winter season variations in physicochemical parameters of marine water characteristics of coral reef of the poshitra coast, paga reef and boria reef of southwest gulf of kachchh, India, International Journal of Scientific & Technology Research, vol. 3, no. 7, pp. 270-273.
- Thirupathaiah, M, Samatha, CH & Sammaiah, C, 2012, Analysis of water quality using physico-chemical parameters in lower manair reservoir of Karimnagar district, Andhra Pradesh, International Journal of Environmental Sciences, vol. 3, no. 1, pp. 172-180.
- Touliabah, H, Safik, HM, Gab-Allah, MM & Taylor, WD, 2002, Phytoplankton and some abiotic features of El-Bardawil lake, sinai, Egypt, Afr. J. Aquat, vol. 27, pp. 97-105.
- Velsamy, G, Manoharan, N & Ganesan, S, 2013, Analysis of physic-chemical variations in sea water samples uppanar estuary, Cuddalore, Tamilnadu, India, International Journal of Research in Biological Sciences, vol. 3, no. 2, pp. 80-83.
- Zhou, F, Guo, HC, Liu, Y & Jiang, YM, 2007, Chemo metrics data analysis of marine water quality and source identification in southern hong kong, Marine Pollution Bulletin, vol. 54, pp. 745-756.