Seasonal Variation of Physical- Chemical Parameters In Five Diferent Stations From South East Coast of India

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Abstract- *Plants and animals life in marine habits and their distribution and productivity is depend on various physical-chemical factors such like salinity, pH, temperature, dissolved oxygen and nutrients like phosphate, nitrate, nitrite, silicate. Atmospheric temperature was ranged between (28.1 and 4.7 °C). The water temperature was ranged between 27.4 and 33.4 °C, Salinity it was ranged between 26 and 35 psu. The (pH) ranged between 7.7 and 8.2. Similarly, the dissolved oxygen (DO) was ranged between 4.028 and 5.827 mg l-1. Nitrite level was ranged between 0.306 and 1.542 µmol l-1. Nitrate was ranged between 2.55 and 10.26 µmol l-1. Ammonia was ranged between 0.048 and 0.647 µmol l-1. Total nitrogen was ranged between 10.871 and 24.698 µmol l-1. Inorganic Phosphate was ranged between 0.268 and 1.036 µmol l-1. The total Phosphorus concentration was ranged between 0.658 and 2.176 (µmol l-1).*

Keywords- Ammonia, Chemical factors, Nitrate, Phosphate, temperature.

I. INTRODUCTION

Plants and animals life in marine habits and their distribution and productivity is depends on various physical-chemical factors such like salinity, pH, temperature, dissolved oxygen and nutrients like phosphate, nitrate, nitrite, silicate [1]. Distribution and behavior of nutrients in the marine environments, particularly in the near coast waters also estuaries exhibit significant seasonal variations depending on the local conditions like discharge of sewage and waters, rainfall, freshwater inflow, tidal incursion and due to the biological activities like benthos regeneration. The increasing demand for marine ornamental fish due to the recent developments in aquarium keeping have resulted in an over exploitation of the normal stock and consequent destruction of reef areas [2]. The forbidden spawning during temperature manipulations to bring about gonadal maturation has been successful with some temperate species. Temperature is one of the most important physical factors influencing fish growth, body composition and energy budget [3]. As temperature is low, growth rates, feeding rates and metabolic rates are suppressed; where important temperatures correlate with an increase in growth up to an optimum point above which thermal stress occurs [4].

Although a large amount has known about the seasonal distribution of nutrients and various biotic processes affecting the nutrient cycle of different coastal environments [5].

Physical-chemical parameters, species composition as well as seasonal variation in phytoplankton abundance have been studied in other regions of Indian coastal water [6 and 7]. For confirming the good quality of water resources large number of physical-chemical parameters, extend and source of any pollution load must be know for which monitoring of physical-chemical parameters and pollutants is essential [8]. The biological wealth of aquatic realm was thoroughly demonstrated by [9].

This biological wealth is largely depends on the dissolved nutrients. Ecological studies are very important in eutrophic areas for determining the changes of water quality and thus the general evaluation of the particular area. Changes in the sea surface temperature in marine water are also a optional indicator for state of the environment reporting [10].
Thus the hydrological study is a requirement in any aquatic system for the assessment of its potentialities, distribution of plants and animals and also to know the realities between its different tropical level and food webs. In Indian estuaries and seas the physico-chemical characteristics have been carried out by many workers [11, 12, 13, 14, 15, 16, 17, 18 and 19]. Hence the present investigation has been made to understand the fluctuation in physical-chemical parameters and their effect on the five different stations along the southeast coast of India.

II. MATERIALS AND METHODS

PHYSICAL - CHEMICAL PARAMETERS

The seawater samples were collected from five different sampling stations from Pondicherry (PDY), Cuddalore (CUD), Porto-Novo (PNO), Karaikkal (KRK) and Nagappattinam (NAG) of Tamil Nadu, Southeast Coast of India by using mechanized vessel (length-42', breath-13', engine-Ashok Leyland 400, power-100 HP), the surface water samples were collected using Nansen water sampler for the duration of one year from January 2013 to December 2013.

The physical-chemical parameters of water samples were analyzed by adopting standard method of [20]. The interpreting data were made from for one year January 2013 to December 2013 in four seasons namely post-monsoon, summer, pre-monsoon and monsoon. Atmospheric temperature and surface water temperature were noted with the help of a Celsius thermometer. Salinity was recorded used a hand Refractometer (Atago, Japan) water pH (Negative logarithm of hydrogen ion concentration was noted by a calibrated pH pen (Tester-Eutech Instruments, Singapore). The dissolved oxygen (DO) concentrations were for fixed estimation was made from Laboratory immediately upon following modified Winkler's method as described by [21].

III. SEAWATER NUTRIENTS

The concentration of seawater nutrients such as Nitrite (NO_2), Nitrate (NO3), Ammonia (NH_4), Total Nitrogen, Inorganic Phosphate, Total Phosphorus (PO_4) and Silicate (SiO_3) were determined using methods for the seek convince and interpretation of data the monthly data were converted into four seasons [22].

IV. STATISTICAL ANALYSIS

Suites of statistical interpretation were carried out using statistical packages SPSS (Version 17) tested the two-way significance (ANOVA) of physical-chemical variables assessed from different stations, seasons and one year. The relationship between the characteristic were calculated by correlation coefficients analysis.

V. RESULTS

Atmospheric temperature (°C)

In the present study, atmospheric temperature was statistically significant between the stations. However, not significant between the seasons ($p<0.05$; Table.1.) and it was ranged between (28.1 and 4.7 °C). Atmospheric temperature was found to be the maximum was recorded in (34.7 °C) at Parangipettai during summer seasons; the minimum was registered in (28.1 °C) at Karaikkal during monsoon seasons (Fig.1a and 1b).

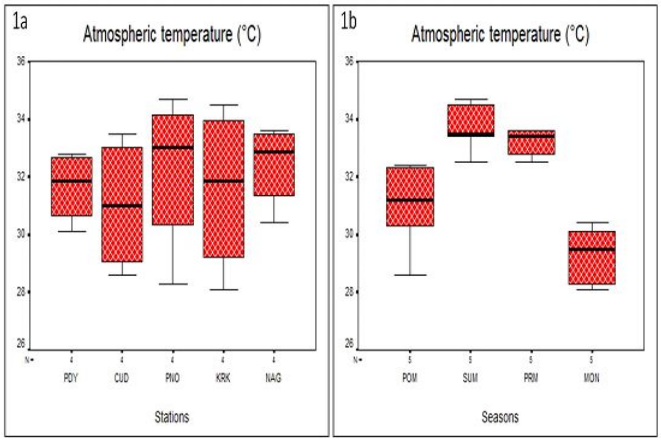

Fig.1.The variation of Atmospheric temperature in stations (1a) and seasons (1b) From January 2013 to December 2013

Water temperature (°C)

The water temperature was ranged between 27.4 and 33.4 °C in different sampling stations and seasons, the maximum was recorded in (33.4°C) at Parangipettai during summer seasons, the minimum was recorded in (27.33°C) at Karaikal during monsoon seasons (Fig.2a and 2b). The water temperature was statistically significant between the stations, not significant between seasons ($p<0.05$; Table.1.).

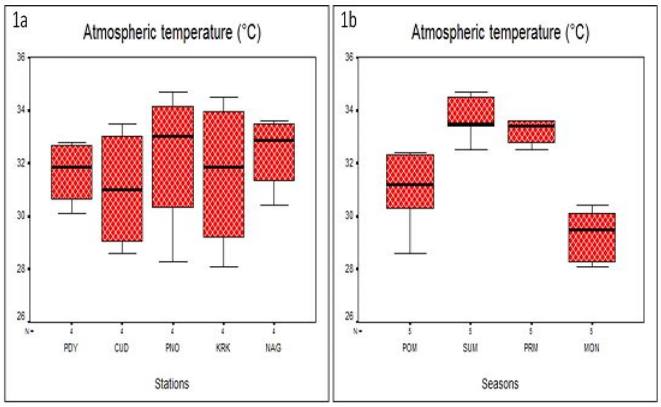

Fig.2.The variation of water temperature in stations (2a) and seasons (2b) From January 2013 to December 2013

Salinity (psu)

Salinity was statistically significant between the stations not with the seasons ($p<0.05$; Table.1.). It was ranged between 26 and 35 psu in different sampling stations, seasons and years, the maximum was recorded in (35 psu) at Karaikkal and Nagappattinam during summer seasons, the minimum was recorded in 26 psu at Parangipettai during monsoon seasons (Fig.3a and 3b).

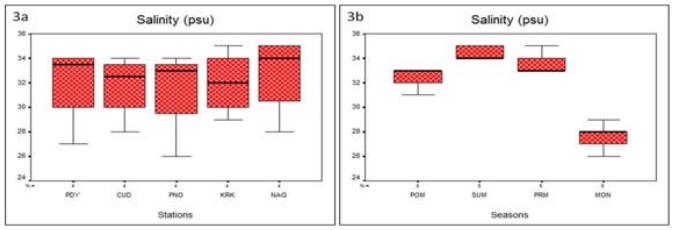

Fig.3.The variation of salinity in stations (3a) and seasons (3b) From January 2013 to December 2013

pH

The hydrogen ion (pH) ranged between 7.7 and 8.2 in among the sampling stations, seasons and years. The maximum was (8.2) recorded at Parangipettai during summer and minimum was recorded (7.7) at Cuddalore during monsoon seasons (Fig.4a and 4b). The pH was statistically significant between the stations and seasons ($p<0.05$; Table.1.).

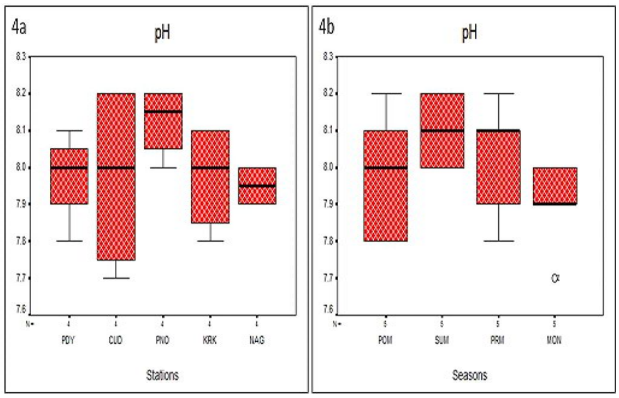

Fig.4.The variation of pH in stations (4a) and seasons (4b) from January 2013 to December 2013

Dissolved Oxygen (mg l-1)

Similarly, the dissolved oxygen (DO) was statistically significant between the stations and seasons ($p<0.05$; Table.1.) and ranged between 4.028 and 5.827 mg l-1 in different sampling stations, seasons. The Dissolved oxygen maximum was recorded in (5.827 mgl-1) at Nagapattinam during monsoon, the minimum was registered in (4.028 mg l-1) at Cuddalore during summer seasons (Fig.5a and 5b).

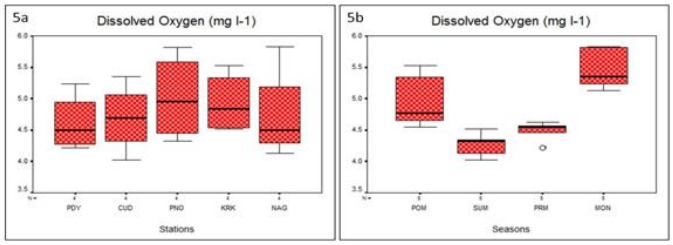

Fig.5.The variation of Dissolved Oxygen in stations (5a) and seasons (5b) from January 2013 to December 2013

Nitrite (µmol l-1)

Nitrite level at all the stations were statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 0.306 and 1.542 µmol l-1 in different sampling stations and seasons, the maximum was registered in (1.542 µmol l-1) at Parangipettai during monsoon seasons, the minimum was recorded in (0.306 µmol l-1) at Cuddalore during summer seasons (Fig.6a and 6b).

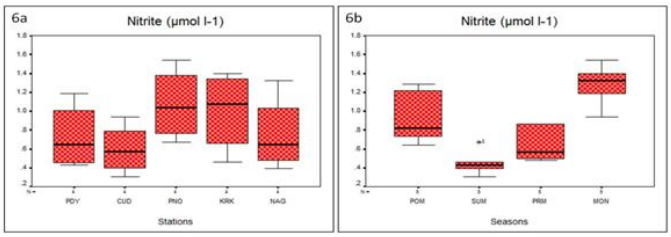

Fig.6.The variation of nitrite in stations (6a) and seasons (6b) from January 2013 to December 2013

Nitrate (µmol l-1)

Nitrate was statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 2.55 and 10.26 µmol l-1 in different sampling stations and seasons, the maximum was recorded in (10.26 µmol l-1) at Karaikkal during monsoon seasons, the minimum was recorded in (2.55 µmol l-1) at Nagappattinam during summer seasons (Fig.7a and 7b).

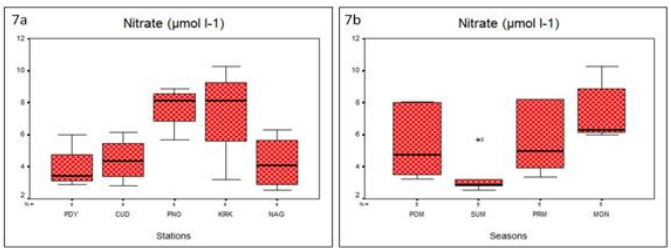

Fig.7.The variation of nitrate in stations (7a) and seasons (7b) from January 2013 to December 2013

Ammonia (µmol l-1)

Ammonia was statistically not significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 0.048 and 0.647 µmol l-1 in different sampling stations and seasons, the maximum was registered in (0.647 µmol l-1) at Parangipettai during monsoon seasons, the minimum was registered in (0.048 µmol l-1) at Cuddalore during summer seasons (Fig.8a and 8b).

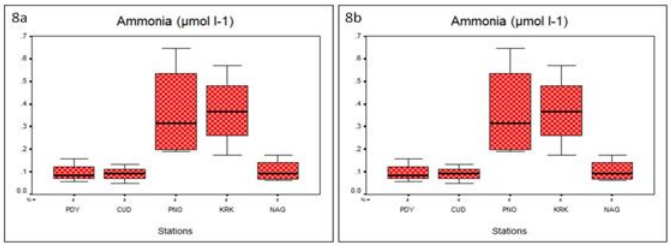

Fig.8.The variation of ammonia in stations (8a) and seasons (8b) from January 2013 to December 2013

Total Nitrogen (µmol l-1)

Total nitrogen was statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 10.871 and 24.698 µmol l-1 in different sampling stations and seasons, the maximum was recorded in (24.698 µmol l-1) at Parangipettai during monsoon seasons, the minimum was registered in (10.871 µmol l-1) at Nagappattinam during summer seasons (Fig.9a and 9b).

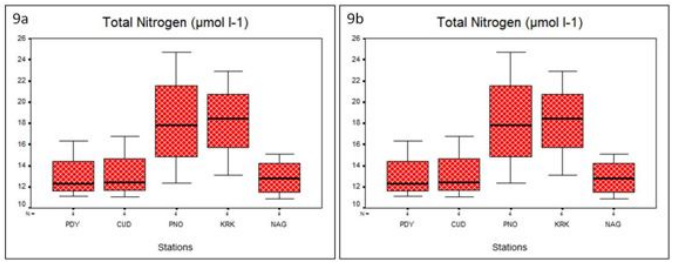

Fig.9.The variation of total nitrogen in stations (9a) and seasons (59) from January 2013 to December 2013

Inorganic Phosphate (µmol l-1)

Inorganic Phosphate was statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 0.268 and 1.036 µmol l-1 in different sampling stations and seasons, the maximum was recorded in (1.036 µmol l-1) at Nagappattinam monsoon seasons, the minimum was recorded in (0.268 µmol l-1) at Karaikkal during summer seasons (Fig.10a and 10b).

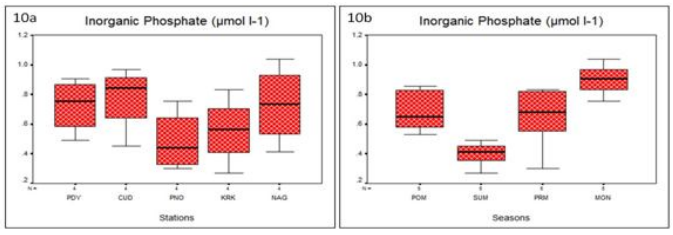

Fig.10.The variation of inorganic phosphate in stations (10a) and seasons (10b) from January 2013 to December 2013

Total Phosphorus (µmol l-1)

The total Phosphorus concentration was statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 0.658 and 2.176 (µmol l-1) in different sampling stations and seasons, the maximum was recorded in the (2.176 µmol l-1) at Nagappattinam during the monsoon seasons, the minimum was recorded in (0.658 µmol l-1) at Karaikkal during summer seasons (Fig.11a and 11b).

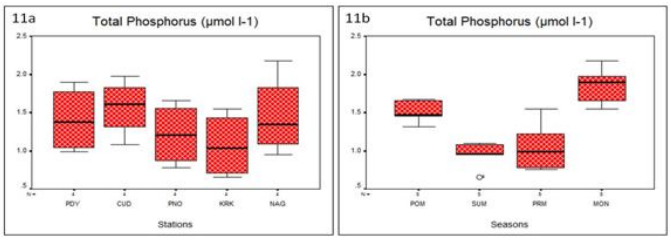

Fig.11.The variation of total phosphorus in stations (11a) and seasons (11b) from January 2013 to December 2013

Silicate (µmol l-1)

Silicate was statistically significant between the stations and seasons ($p<0.05$; Table.1.). It was ranged between 10.34 and 21.358 (µmol l-1) in different sampling stations and seasons, the maximum was recorded in (21.358 µmol l-1) at Parangipettai during monsoon seasons, the minimum was registered in (10.34 µmol l-1) at Karaikkal during summer seasons (Fig.12a and 12b).

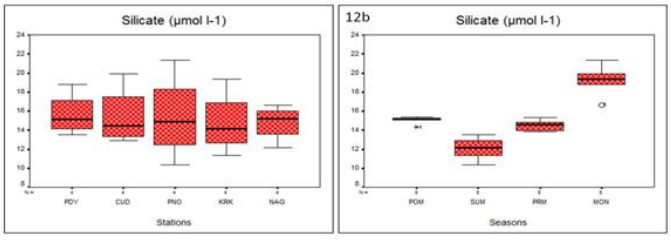

Fig.12.The variation of silicate in stations (12a) and seasons (12b) from January 2013 to December 2013

Table.1. Shows the analysis of variance (ANOVA) analysis, Degree of freedom: P<0.05 - Significant; NS- Not significant

Atmospheric temperature (°C)						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	63.2295	3	21.0765	18.8562	3.49029	p<0.05
Seasons	5.063	4	1.26575	1.13241	3.25917	NS
Error	13.413	12	1.11775			
Total	81.7055	19				
Water temperature (°C)						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	61.548	3	20.516	15.5209	3.49029	p<0.05
Seasons	1.902	4	0.4755	0.35973	3.25917	NS
Error	15.862	12	1.32183			
Total	79.312	19				
Salinity (psu)						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	139.2	3	46.4	59.871	3.49029	p<0.05
Seasons	3.5	4	0.875	1.12903	3.25917	NS
Error	9.3	12	0.775			
Total	152	19				
pH						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	0.104	3	0.03467	1.625	3.49029	p<0.05
Seasons	0.08	4	0.02	0.9375	3.25917	p<0.05
Error	0.256	12	0.02133			
Total	0.44	19				
Dissolved Oxygen (mg l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	4.31867	3	1.43956	17.1222	3.49029	p<0.05
Seasons	0.45459	4	0.11365	1.35172	3.25917	p<0.05
Error	1.00891	12	0.08408			
Total	5.78217	19				
Nitrite (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	1.93401	3	0.64467	56.137	3.49029	p<0.05
Seasons	0.63323	4	0.15831	13.7852	3.25917	p<0.05
Error	0.13781	12	0.01148			
Total	2.70505	19				
Nitrate (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	41.9714	3	13.9905	15.1777	3.49029	p<0.05

Seasons	54.5087	4	13.6272	14.7835	3.25917	p<0.05
Error	11.0614	12	0.92178			
Total	107.542	19				
Ammonia (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	0.13895	3	0.04632	5.85595	3.49029	NS
Seasons	0.35431	4	0.08858	11.1993	3.25917	NS
Error	0.09491	12	0.00791			
Total	0.58817	19				
Total Nitrogen (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	142.038	3	47.3459	20.7886	3.49029	p<0.05
Seasons	129.464	4	32.366	14.2113	3.25917	p<0.05
Error	27.3299	12	2.27749			
Total	298.831	19				
Inorganic Phosphate (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	0.64001	3	0.21334	25.0364	3.49029	p<0.05
Seasons	0.25594	4	0.06398	7.50899	3.25917	p<0.05
Error	0.10225	12	0.00852			
Total	0.99821	19				
Total Phosphorus (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	2.59635	3	0.86545	39.094	3.49029	p<0.05
Seasons	0.64125	4	0.16031	7.24158	3.25917	p<0.05
Error	0.26565	12	0.02214			
Total	3.50324	19				
Silicate (µmol l^{-1})						
Source of Variation	***SS***	***df***	***MS***	***F***	***F crit***	***P-value***
Stations	132.4	3	44.1332	29.4875	3.49029	p<0.05
Seasons	2.55817	4	0.63954	0.42731	3.25917	NS
Error	17.9601	12	1.49668			
Total	152.918	19				

VI. DISSCUSION

The Physical and chemical character such as atmospheric temperature, water temperature, salinity, pH, Do, nitrite (NO2), nitrate (NO3), ammonia (NH4), total nitrogen, inorganic phosphate, total phosphorus (PO4) and silicate (SiO3) of the seawater were tested from five different seasonal sampling stations (Pondicherry, Cuddalore, Parangipettai, Karaikkal and Nagappattinam) and the four seasonal sampling period namely, (Post monsoon, Summer, Pre monsoon and Monsoon) under the year of 2013. Rainfall is the majority important cyclic phenomenon in tropical countries as it brings about important changes in the physical and chemical character of the coastal atmosphere. The rainfall in India is largely influenced by two monsoons viz., southeast monsoon seasons on the west coast and northeast monsoon seasons on the east coast [17].

The observed high value of temperature in might possibly was due to the concentration of solar radiation and evaporation freshwater flood and cool and mix up with ebb tide and flow from adjoining neritic waters. The observed low value of October was due to strong land Sea breeze and rainfall [22]. Atmospheric temperature was statistically significant between the stations, seasons during the study period from January 2013 to December 2013 ($p<0.05$). Atmospheric temperature was ranged between 28.1 and 34.7 °C and the maximum was recorded in summer and the minimum in monsoon. In the case of seawater temperature was ranged between 27.4 and 33.4 °C and the maximum was recorded in summer seasons and the minimum was in monsoon in five different stations under years of 2013. The higher float up water temperature was registered during the summer season might be possibly due to influenced by the intensity of solar radiation, evaporation, less in freshwater influx and controversial and mix up with ebb and flow from adjoining neritic water [23 and 6].

The lower values of surface water temperature recorded in monsoon season may be possibly due to strong land sea breeze and controversial statement precipitation [24 and 25]. Similar pealed of during summer weal observed earlier by several workers in the west coast and east of India [26 and 27]. Salinity is one of the important key factors which find out the composition of organic component in the marine environment. The fluctuations during the salinity affect the biological characteristics of the environment.

Salinity was statistically significant between the stations and seasons ($p<0.05$). It was ranged between 26.00 and 35.00 (psu) from five different sampling stations. In the case of the seasons the maximum was recorded in during summer and minimum was in monsoon. In the present study, salinity in all the stations was high level during the summer season and low level during the monsoon season. Higher values during summer may be alive attributed to high degree of disappearance and also due to control of neritic water from open aquatic [22, 1, 28 and 29]. Resting on the other hand during the monsoon seasons, rainfall and the resulting freshwater inflow from the land run off in turn would have moderately reduced the salinity. High salinities were recorded across the stations in the dry months (December -April) than wet months (May-November) this might be due to intensity of the water by the increase freshwater input during these wet months. This was in accord with information of [30].

Dissolved oxygen was statistically significant between the stations and seasons but not with years ($p<0.05$). It was ranged between 4.028 and 5.827 mg.l-1 the five different sampling stations. In the case of the seasons, the maximum was recorded in monsoon and minimum in summer. Season-wise observation of dissolved oxygen showed an opposite trend beside temperature and salinity. It is well well-known that temperature and salinity influence closure of oxygen in salt water [31]. In the present study, high dissolved oxygen concentration observed throughout the monsoon seasons might be due to the increasing effect of higher wind rate coupled with intense rainfall with the follow-on fresh water mixing [32 and 33]. Exposed that the seasonal variant of dissolved oxygen mostly to fresh water appearance and ferruginous impact of sediments. Comparatively lower values found during the summer seasons could be mainly due to reduced shakeup and turbulence of the coastal waters.

The deepness of water at a exacting site in a water body is one of the major physical factors which act as a scheming issue for determining the water quality. Among the dissimilar site, a highest depth of 5.5 m was maintained at site III in May and a smallest amount of 0.3 m at site V in January. The lowly mean depth is an indication of an evolutionary process coinciding with high trophic status of the lake as well opined by [34, 35, 36 and 37]. The precision of water fluctuate both spatially and temporally. In common, the maximum transparency values were recorded in winter season seasons (1.7 m at site III) and lowest in summer season (0.6 m at site V). Higher clearness value during the winter season might be due to sedimentation of suspended soil particles (Singh, 1990) and low balanced organic matter by poor planktonic growth [38]. On the basis of inter-correlation matrix precision showed positive correlation among dissolved oxygen [39].

The pH was statistically main between the stations and seasons ($p<0.05$). Hydrogen ion concentration (pH) (7.7 to 8.2) in sea water remained alkaline throughout the study period in all the station with the maximum values happening in the summer season and minimum value stirring in the post monsoon season. Generally, pH showed significantly positive correlations with sea water temperature. This is into conformity among the observations of [40 and 41]. Further more, opposite relationship of pH with nitrate as recorded in the present study agrees well with the study of [42]. Further, fluctuations in pH values during different seasons of the year is attributed to factors like removal of CO2 in photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity in addition to temperature and decomposition of organic matter [43 and 44].
Nutrients are considered since one of the mainly important parameters in the marine environment influencing development, imitation with metabolic activities of biotic components. Division of nutrients is essentially based on season, tidal condition and fresh water flow from land. Nitrite, nitrate and ammonia was statistically significant between

stations and seasons ($p<0.05$). The increased nitrate level is due to fresh water inflow, mangrove leaves (litter fall) decomposition and terrestrial runoff during the monsoon season [45]. The records of an inferior value of nitrate might be live due to its consumption by phytoplankton as evidenced by high photosynthetic action and also due to the neritic water dominance, which restricted only negligible amount of nitrate [46]. In the present study, upper value of nitrite and ammonia was recorded during monsoon seasons might be due to various reasons including difference in zooplankton, oxidation of ammonia and reduction of nitrate through recycling of nitrogen and bacterial decomposition of planktonic accumulation present in the environment [29]. Also due to gentrification and air maritime interaction exchange of chemicals [44 and 24].The recorded low nitrite value during summer season may be due to high controlled statement [6].

Behavioral as well as distribution of nutrients such as nitrate, nitrite, phosphate and silicate in the coastal waters would show considerable seasonal variations depending on the local conditions of rain fall quantum of fresh water in flow, tidal incursions and nutrients utilization in phytoplankton biomass and restoration. Low concentration of nutrients observed during the summer season may perhaps, due to a decrease in fertilizer waste disposal from the terrestrial region and consumption of nutrients by phytoplankton biomass [8, 47 and 58].

Nitrate is a essential nutrient but at higher concentration is poisonous and is capable of worrying the marine environment. Nitrate level was recorded in less than 0.5 mg/l will not contaminate the water [49]. In the present study the nitrate value was recorded 8.07 mg/l in Muttukadu estuary and 5.11 mg/l in the coastal water, similar trend was previous reported by [50].In Gosthani estuary, east coast of India [51] in marine waters of Palk-Strait, India. Non-living nitrite concentration was establish to be lower than nitrate probably due to its very constant nature and it perhaps gets directly converted to ammonia or nitrate and evaporate and its cyclic distributions was comparable that of nitrate [52]. The excess concentration of nitrate and nitrite determination lead to extreme marine plant production, which may harmfully impact estuary water environments leading to reduce dissolved oxygen with production of toxic algae. As a effect of oxygen depletion, disease and death of marine organisms will take place [53].

Total nitrogen was statistically significant between the stations and seasons but not with years ($p<0.05$). It was ranged between 10.871 and 24.698 µmol l-1 from the five different sampling stations. In the casing of the seasons the maximum was recorded in monsoon seasons, the minimum was register in summer seasons. In the present study maximum value of nitrate and total nitrogen during monsoon season can be mainly due to the organic materials received from the catchment area in ebb tide [24]. An additional possible way of nitrate input could be during oxidation of ammonia form of nitrogen to nitrite configuration [44]. The minimum values observed during the non-monsoon period may be due to its utilization by phytoplankton as evidenced through high photosynthetic movement and the dominance of neritic seawater having a negligible quantity of nitrate [54 and 55].

Silicate was statistically significant between the stations and seasons ($p<0.05$). Some general information about the trend of present study result was ranged between 10.34 and 21.358 µmol l-1 and the maximum was recorded in monsoon and minimum in summer seasons. The silicate content was higher than that of the extra nutrients and the recorded high in monsoon values could be due to large influx of fresh water derivative from land drainage moving silicate leached out from runoff and also from the bottom sediment [46 and 44].The deletion of silicates by adsorption and co-precipitation of soluble silicate with humid compounds and iron [44].

The observed low down in summer values could be attributed to uptake of silicates with phytoplankton for their organic activity [24 and 6]. Silica concentration in the Muttukadu estuary was recorded 2.06ppm, where in the coastal water it was ranged in 1.11ppm.The high silicate concentration was due to the adding of silica material by land run off caused by flooding and low due to the sizeable reduction in the fresh water input and better consumption of this nutrient by the abundantly happening phytoplankton for their biological activity [56].

Inorganic Phosphate and total phosphorus was statistically significant between the stations and seasons ($p<0.05$), High concentration of inorganic phosphate observed in monsoon season elevated is possibly due to intrusion of flow seawater, which increased the level of phosphate [59].

Further, regeneration and discharge of total phosphorus from bottom mud into the water line by turbulence and mixing also contributed to the higher values during monsoon the total phosphorus were found to be increased during monsoon periods and decreased slowly from summer seasons onwards.

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