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Research Article

Assessment of water quality along the coast of Arabian Sea

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Abstract

The present work was focused on the spatial and temporal variations of the coastal water quality from six shores along southwest coastline in Arabian sea in Kanyakumari District,Tamilnadu, India. The surface temperature was found varied from 21.2°C to 28.1°C, pH was varied from 7.66 to 8.9, conductivity, TDS, DO, CO_2, Alkalinity and nitrate remains almost same in all places in a particular season. Turbidity was ranged between 2 NTU to 11 NTU and maximum in Kanyakumari in all seasons. The observed DO was above 5 mg/l. Minimum BOD was observed in the present study. Carbon dioxide was found varied from 8 ppm to 25 ppm. Total alkalinity values lie within the maximum permissible limit. Both gross alpha and gross beta count were maximum in Muttom coastal water. Nutrient nitrate varied from 2 g/l to 4 g/l. Phosphate was much higher in Muttom in summer season. Sulphate was higher in Kanyakumari and Thengapattanam coast which indicates anthropogenically affected water quality.

Keywords: Coastal water; Alkalinity; Turbidity; Spatial and temporal variation.

Introduction

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. About 71% of the world we live in is occupied by oceans. The oceans cover 361 billion sq. km of earth and contain 1368 billion cubic kilometers of water. The Indian Ocean extends from Antarctica to the continent of Asia including the Red Sea and Persian Gulf. The Arabian Sea and South China Sea are marginal seas. Compared to the open ocean systems, the coastal region exhibits environmental gradients occurring spatially and temporally on micro or macro-scale. Estuarine and coastal waters always maintained an intimate relation with the developmental activities of man. Marine pollution is one of the most serious problems of environment that poses a major threat to the human health. Around the world, pollution has increased in prevalence by the growing industrialization and the population explosions (Kennish et al., 1997). Seawater resources are considered to be one of the major components of environmental resources that are under threat either from over exploitation or pollution (Efe et al., 2001).

Besides the natural changes which bring about variation in physical and chemical parameters of water, human interventions also create powerful disturbances on the marine environment. The maximum production was reported nearer to the coasts, within 50 m depths and gradually decreasing seaward (Nair et al., 1973). The valuable resources are exploited by fishing which is one of the major man made activities in the sea (Jennings et al., 2001). 'These differing atmospheric regimes produce drastic physical, chemical and biological changes in the water column (Banse et al., 1959; Pankajakshan et al., and Ramaraja et al., 1987). A series of studies have been conducted on the physico - chemical parameters of the open Arabian Sea (Jayaraman et al., 1959; Banse et al., 1959; Rao et al., 1984) south west coast of India is well known for its surface production compared to the other coasts.

An integrated study of physico-chemical parameters has not been carried out so far along these regions, which lead to take up this study. With a view to delineate environmental changes of such a vulnerable region, detailed chemical oceanographic studies have been undertaken to monitor water quality of coastal waters of south west coast of Kanyakumari District.. The survey provides important background information necessary for the study of the coastal processes.

The objective of this study is to evaluate the chemical oceanographic parameters of the coastal waters of Arabian sea in Kanyakumari district in Tamilnadu at different seasons to understand the probable changes that may arise in the coastal waters based on the behavior of some of the parameters like pH, Temperature, Turbidity, Conductivity, Total dissolved solids, Dissolved oxygen, Biological oxygen demand, Alkalinity and radioactivity and nutrients nitrate, phosphate and sulphate.

Materials and methods

Kanyakumari District is one of the 32 districts in Tamilnadu. It is located at the southernmost tip of peninsular India. It is sometimes referred to as "land's End'. It lies between 77o 15' and 77 o 36' of the eastern longitudes and 8 o 03' and 8 o 35' of the northern latitudes. Its south eastern boundary (coastal) is Bay of Bengal, while on the south and south west, the boundaries are the Indian Ocean and Arabian Sea (Fig. 1). Since this district is located at the extreme south of the Indian subcontinent, the coastline is formed nearly by three seas; the Arabian Sea, the Indian Ocean and the Bay of Bengal while the main part of the coast of Kanyakumari district faces the Arabian Sea. The Arabian coast is well known for the rich variety of fishes. Kanyakumari district was one of the worst affected districts in India in the tsunami that ravaged the coasts of various countries in South and South East Asia, on 26 December 2004. Since this district is located at the extreme south of the Indian subcontinent, the coastline is formed nearly by three seas; the Arabian Sea, the Indian Ocean and the Bay of Bengal while the main part of the coast of Kanyakumari district faces the Arabian Sea.

The present study was carried out in six coasts such as Kanyakumari (place 1) which is an important tourist centre, Manakudy (place 2, Chothavilai (place 3, Muttom (place 4), Colachel (place 5) and Thengapattanam (place 6). Manakudy, Muttom and Colachel coast are predominantly occupied by fishermen. Thambaraparani river confluences with the Arabian Sea near Thengapattanam. The Valliar collects the drainage from P.P. Channel and its branches and confluences with the Arabian Sea near Manavalakurich which is nearer to Muttom. Manakudy estuary formed by the confluence of river Pazhayar in between East and West Manakudy villages. Pambarestuary confluences near Colachel. The present study was carried out over a period of 12 months from June 2014 to May 2015.

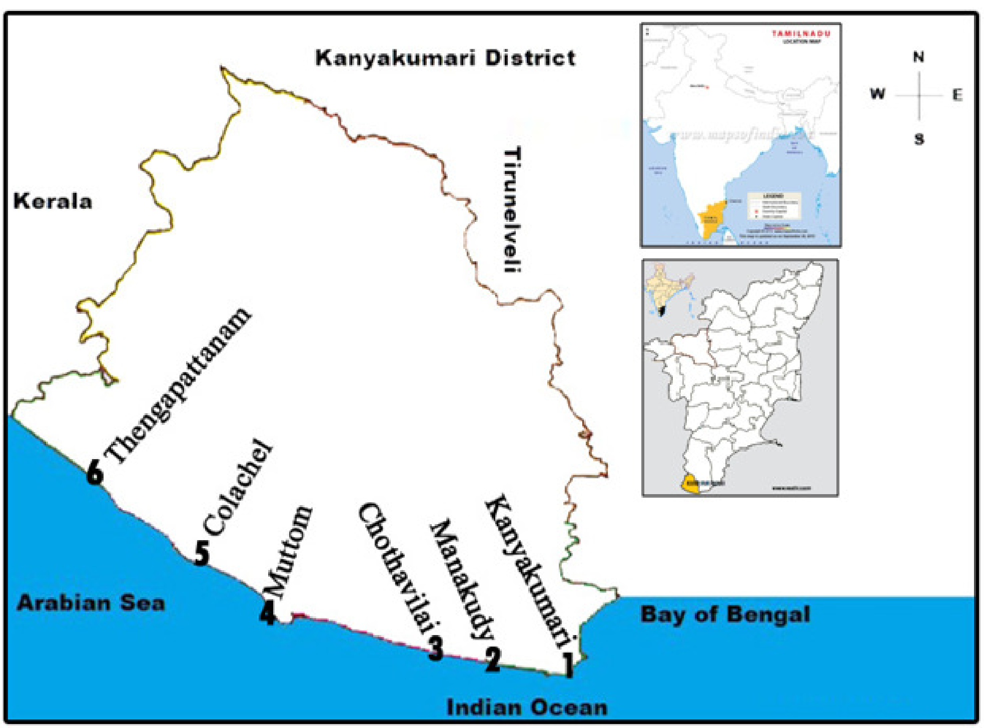

Fig. 1. Map showing the locations of the selected shores from where the sampling was done

Throughout the study period sampling of water was carried out on a monthly basis on the first week of every month between 6 am to 8 am. Each sampling stations were visited monthly and six samples of surface seawater were collected from different locations of the same coast. However, the locations for the collection of samples in a particular coast were fixed. In the present study 12 months have been divided in to four seasons prevailing in this region viz monsoon (June to August), postmonsoon (September to November), winter (December to February) and summer (March to May).

Sea water samples were collected every month with a clean plastic can from six different stations. Samples for nutrient analysis were collected in pre-cleaned polythene bottles. Preservation and transportation of the water samples to the laboratory were as per standard methods. Some physical parameters like seawater temperature, pH, conductivity and turbidity were measured directly in the field using portable multi parameter analyzer. Parameter TDS was determined gravimetrically. Samples for DO and BOD were collected in BOD bottle and analyzed later. Carbondioxide and total alkalinity are estimated volumetrically. Nitrate, sulphate and phosphate are estimated in the laboratory by following standard methods (Grasshoff et al., 1999). Radioactivity was measured by alpha and beta counting system. The analytical procedures for all parameters were adopted from APHA and Trivedi and Goel (1986). All the chemicals used were of analytical grade. The results were analyzed and presented for four different seasons. The seasonal variations of all parameters are shown in Tables 1 to 13.

Results and discussions

Surface temperature

Sea surface temperature (SST) is the water temperature close to the ocean's surface. The exact meaning of surface varies according to the measurement method used, but it is between 1 mm to 20 m below the sea surface. Temperature effects on water quality can be physical, chemical and biological. Chemically temperature affects not only the rate of reaction but also the extent to which the reactions take place. Temperature is one of the most important factors in the coastal ecosystems, which influences the physical-chemical characters of coastal water (Sundaramanickam et al., 2008). During the study period surface water temperature varied from 21.2 to 28.1. The minimum surface water temperature was recorded during winter and maximum was recorded during summer. All the station showed similar seasonal changes. Surface water temperature is influenced by the intensity of solar radiation, evaporation, fresh water influx and cooling and flow from adjoining waters (Govindasamy et al., 2000).

Table 1. Sea surface temperature of seawater from different coasts of Arabian Sea in Kanyakumari District. Values expressed are mean±SD

Place	Monsoon	Post monsoon	Winter	Summer
1	23.1±0.2	25.6±0.1	21.2±0.3	26.8±0.1
2	24.4±0.1	26.2±0.1	21.4±0.3	27.6±0.2
3	24.7±0.3	26.1±0.3	21.8±0.2	27.2±0.2
4	24.5±0.1	26.8±0.2	22.7±0.1	28.1±0.1
5	24.2±0.2	25.3±0.1	21.8±0.4	27.8±0.3
6	23.4±0.4	25.9±0.3	21.5±0.1	27±0.3

pH

Ocean acidification is the ongoing decrease in the pH of the Earth's oceans, caused by the uptake of carbon dioxide (CO2) from the atmosphere (Caldeira et al., 2003). Between 1751 and 1994 surface ocean pH is estimated to have decreased from approximately 8.25 to 8.14. Increasing acidity is thought to have a range of possibly harmful consequences, such as depressing metabolic rates and immune responses in some organisms, and causing coral bleaching. Ongoing acidification of the oceans threatens food chains connected with the oceans (Powell et al., 1998). The pH of water is important because many biological activities can occur only within narrow range (Shepherd et al., 1992). Also pH is most important in determining the corrosive nature of water. Lower the pH higher is the corrosive nature of water. The range of pH expected for normal seawater is from 8.0 to 8.30 and that for coastal waters is from 7.9 to 8.2, pH remained alkaline throughout the study period. Fluctuations in pH values during different season of the year were attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation of water with fresh water influx, reduction in salinity and temperature and decomposition of organic matter (Rajasehar et al., 2002). From the

Fig. 3 it may be noted that pH remain between 7.3 to 7.9 in monsoon season. Remaining other three season's pH lies between 7.6 to 8.9. The high value of pH is reported in post monsoon season at Manarkudi coast (8.9). Similarly the upwelled waters also influence the sea water pH to rise. Moderate pH of 8 to 8.9 prevailed in all season except monsoon. Low pH values observed during monsoon may be due to the large influx of runoff associated with monsoon which contain substantial amount of domestic and other industrial wastes. High pH value is recorded in Muttom during post monsoon which may be due to high anthropogenic activities in this location became of Muttom harbor where human interference to the coastal line is high throughout the year. Kanyakumari is seasonal tourist centre where the human activity reaches to its maximum during winter months where moderate pH is recorded.

Table 2. pH of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are mean±SD

Place	Monsoon	Post monsoon	Winter	Summer
1	7.84±0.03	8.61±0.09	8.01±0.12	8.26±0.03
2	7.7±0.13	8.9±0.03	8.4±0.11	8.13±0.05
3	7.9±0.08	8.4±0.05	8.2±0.02	8.4±0.11
4	7.9±0.11	8.8±0.06	8.4±0.06	8.5±0.07
5	7.66±0.02	8.35±0.04	8.1±0.08	7.92±0.08
6	7.8±0.04	8.53±0.13	8±0.01	8.21±0.06

Turbidity

Turbidiy is a measure of water clarity and how much the material suspended in water decreases the passage of light through water. Turbidity serves as a main factor in governing light penetration. Least amount of turbidity indicates bright sunshine, clear water condition, removal of suspended materials from the water column and cessation of fresh water, thereby reducing turbidity (Anitha et al., 2013). High turbidity value may be due to fresh water discharges which carried out lot of erogenous materials and low solar radiation (Kalaiarasi et al., 2012). Turbidity values varied from 2 to16 NTU. Maximum turbidity observed in monsoon and post monsoon seasons possibly due to rain water runoff during southwest monsoon season prevailing in these areas (Misra et al., 2005). According to Patil et al., 2012), higher level of turbidity is associated with disease causing bacteria. The variations of turbidity depend on the inflow of rain water carrying suspended particles (Begum et al., 2006). Turbidity did not show any statistically significant spatial and temporal variations between the coasts except Kanyakumari coast. Except Kanyakumari, in other coasts, turbidity varies between 2 to 8 NTU. Among various seasons turbidity is maximum in monsoon and next in post monsoon season. Turbidity is maximum in Kanyakumari coast in all seasons and reaches maximum in post monsoon and winter seasons may be due to higher human interference in this place because of festive seasons. Turbidity remains nearly same in all seasons in Thengapattanam coast and minimum turbidity is recorded here indicates bright sunshine, clear water condition, removal of suspended materials from the water column and cessation of fresh water, thereby reducing turbidity.

Table 3. Turbidity of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are mean±SD

Place	Monsoon	Post monsoon	Winter	Summer
1	10±0.06	11±0.04	11±0.06	9±0.08
2	7±0.02	7±0.04	3±0.02	2±0.04
3	6±0.04	8±0.02	5±0.04	3±0.06
4	6±0.08	4±0.03	4±0.02	4±0.08
5	7±0.02	4±0.06	4±0.08	4±0.04
6	3±0.02	2±0.02	3±0.02	3±0.02

Conductivity

Conductivity is the ability of water to conduct an electric current and the dissolved ions are the conductors. Rain runoff decreases the conductivity because rain is essentially distilled water. (Boyd et al., 1981), suggested that the fluctuation in electrical conductivity was due to fluctuation in total dissolved solids and salinity. According to (Clair et al., 1994), the relation between total dissolved solid and electrical conductivity is a function of the type and nature of the dissolved cations and anions in the water. According to (Hallale et al., 2012), conductivity is higher in summer season while lower in rainy season. Sea water's conductivity is one million times higher than that of deionized water. Salinity is the component of conductivity that is critical to the survival of some aquatic plants and animals. The concentration of nitrate and phosphate increase the conductivity. It is also useful measurement to determine the salinity which is the main variable in regulating the concentration of dissolved materials. In the present study conductivity is maximum in summer seasons in all coasts in accordance with (Hallale et al., 2012). Also it is the highest in Kanyakumari coast (ie) 51 mS. Conductivity prevailed minimum in Monsoon season and next in post monsoon season may be due to rain water runoff which decreases conductivity. Moderate conductivity is recorded in winter season in all places. Least conductivity in recorded in Colachel coast (ie) 30 mS during monsoon season.

Table 4. Conductivity of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are mean±SD

Place	Monsoon	Post monsoon	Winter	Summer
1	36±0.12	37±0.14	44±0.09	51±0.13
2	35±0.11	37±0.09	41±0.07	49±0.12
3	33±0.08	35±0.12	42±0.11	50±0.14
4	36±0.07	38±0.13	41±0.12	50±0.09
5	30±0.14	36±0.11	44±0.14	46±0.06
6	33±0.05	34±0.07	43±0.11	48±0.14

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size, or smaller) pores. Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants.

According to (Jingsui Huang et al., 2013), TDS test is used as an indicator test to determine the general quality of the water and high concentrations of TDS may reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature. Also, the concentration of TDS affects the water balance in the cells of aquatic organisms. According to Water Quality Association; TDS value for sea water is 30,000-40,000 ppm.

Table 5. TDS(g/l) of seawater from different coasts of Arabian sea in Kanyakumari district . Values expressed are Mean ± SD

Place	Monsoon	Post monsoon	Winter	Summer
1	30.59±0.08	27.49±0.07	24.56±0.05	33.45±0.12
2	30.84±0.04	27.78±0.08	24.86±0.03	30.55±0.14
3	31.10±0.05	27.78±0.02	26.64±0.02	32.00±0.09
4	30.84±0.06	29.25±0.11	24.32±0.07	31.71±0.01
5	31.86±0.02	29.84±0.08	25.46±0.05	29.68±0.08
6	33.13±0.09	31.60±0.06	29.56±0.08	33.74v0.05

Dissolved Oxygen

DO is one of the most important parameter. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata Vikal et al., 2009). In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss et al.,1972; Morrissette et al., 1978). The high DO in summer is due to increase in temperature and duration of bright sunlight has influence on the % of soluble gases (O_2 & CO_2). During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. This possibly accounts for the greater qualities of O_2 recorded during summer (Krishnamurthy et al., 1990). DO is essential to the metabolism of all aquatic organisms that posses aerobic respiratory biochemistry and the maximum oxygen requirement for fish life is 3mg/L (Sreenivasan et al., 1970). Low DO concentration threats the survival of aquatic organisms except anaerobic microbes (Divya Tiwari et al., 2012). DO could be attributed due to the entry of untreated sewage and other organic wastes in to the water body (Michael et al., 1984).

Higher dissolved oxygen observed during the monsoon season might be due to the cumulative effect of higher wind energy coupled with heavy rain fall and the resultant fresh water mixing (Anitha et al., 2013). The same observation was reported by (Damotharan et al., 2010). Minimum value of DO may be due to the disposal of domestic sewage, agricultural runoff and coconut husk retting wastes. Dissolved oxygen content varied from 5.1 to 6.3. Maximum value of DO was observed at Kanyakumari and Manakudy during winter and post monsoon seasons. Minimum value of DO was observed in summer in Colachel coast. In general maximum and minimum values of DO were recorded during post monsoon and summer season at all stations. Higher DO observed during post monsoon and winter might be due to the heavy rain fall, fresh water mixing and higher wind energy. Minimum value recorded at Colachel coast might be due to the disposal of domestic sewage and coconut husk retting wastes through Pampar estuary. The observed DO: was above 5 mg/l which is also reported earlier in the Arabian Sea (Raghunathan et al., 2004). The DO was lower during summer when the temperature was high and maximum during post monsoon and winter when the temperature was low and high tidal activity due to windy monsoon conditions (Faragallah et al., 2009). The inverse relationship between temperature and DO is a natural process (Sheathe et al., 2007).

Table 6. DO (ppm) from different coasts of Arabian sea in Kanyakumari district. Values expressed are in Mean ± SD

Place	Monsoon	Post monsoon	Winter	Summer
1	5.7±0.05	6.2±0.04	6.3±0.01	5.4±0.01
2	5.9±0.01	6.3±0.2	6.1±0.08	5.2±0.07
3	5.7±0.11	6.2±0.21	6.1±0.04	5.2±0.06
4	6.1±0.2	6.2±0.14	6±0.06	5.3±0.07
5	6±0.1	6.1±±0.18	5.9±0.09	5.1±0.11
6	6.2±0.24	6.2±0.09	5.8±0.13	5.2±0.12

Biological Oxygen Demand

Biological oxygen demand reveals the content of micro organisms present in the water under investigation and its organic matter load. BOD is a measure of organic material contamination in water. Higher BOD value indicates the extend of pollution (Jenila et al., 2012). Water bodies with BOD value exceeding 8 mg/l have been regarded as moderately polluted (Martlin et al., 1970). High BOD values indicated the presence of high concentration of biodegradable pollutants. Biological oxygen demand is a useful parameter for assessing the biodegradability of dissolved organic matter in water. At the same time this parameter is used to evaluate the efficiency with which certain processes remove biodegradable natural organic matter (Simon et al, 2016).With the DO level beyond 5 mg/l level the BOD and COD would be minimum (Paul et al., 2006) which was observed in this study . Minimum value was recorded during post monsoon in Cothavilai coast and maximum during summer season in Kanyakumari coast where DO is minimum in that season. Overall BOD level is below 1ppm which indicates less amount of biodegradable pollutants in these coasts.

Table 7. BOD (ppm) of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are Mean ± SD

Place	Monsoon	Post monsoon	Winter	Summer
1	0.75±0.02	0.56±0.01	0.58±0.01	0.89±0.03
2	0.71±0.01	0.53±0.01	0.55±0.02	0.74±0.04
3	0.69±0.02	0.51±0.03	0.54±0.01	0.7±0.02
4	0.65±0.04	0.57±0.02	0.59±0.01	0.71±0.03
5	0.7±0.03	0.58±0.04	0.6±0.02	0.69±0.03
6	0.63±0.01	0.53±0.07	0.53±0.01	0.69±0.02

Carbon dioxide

The ocean contains about sixty times more carbon in the form of dissolved inorganic carbon than in the pre-anthropogenic atmosphere. Ocean is the largest inorganic carbon reservoir in exchange with atmospheric carbon dioxide and as a result the ocean exerts a dominant control on atmospheric CO_2 levels. Dissolved carbon dioxide in the ocean occurs mainly in three inorganic forms: free aqueous carbon dioxide ($CO_{2(aq)}$), bicarbonate($HCO3^-$) and carbonate ion ($CO3^{2-}$). A minor form is true carbonic acid(H_2CO_3) whose concentration is less than 0.3% of ($CO_{2(aq)}$). The sum of [$CO_{2(aq)}$] and [H_2CO_3] is denoted as [CO_2]. The dissolved carbonate species in seawater provide an efficient chemical buffer to various processes that change the properties of sea water. High concentrations of dissolved carbon dioxide are corrosive and have been known to kill fish. The combustion of fossil fuels and production of chemicals have led to a flux of CO_2 to the atmosphere. Presently about one third of anthropogenic emissions of CO2 are believed to be entering the ocean (Takahashi et al., 2002).

Most of the CO2 emitted by human activities will dissolve in the ocean (Archer et al., 2005). Carbon dioxide is end product of organic carbon degradation in almost all aquatic environments and its variation is often a measure of net ecosystem metabolism (Smith et al., 1997, Hopkinson et al., 1985). Therefore in aquatic biogeochemical studies, it is desirable to measure parameters that define the carbon dioxide system. In the present study the results agree with Reid (l961) that pH values vary inversely with free carbon dioxide. The free carbon dioxide concentration was with a maximum of 25 ppm in the rainy season and minimum of 8 ppm in the post monsoon and winter season. It again increased upto 16 ppm in the summer season.

Table 8. Carbon dioxide (ppm) of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are Mean ± SD

Place	Monsoon	Post monsoon	Winter	Summer
1	25±0.05	11±0.04	10±0.02	16±0.02
2	23±0.04	9±0.05	8±0.01	15±0.01
3	24±0.09	9±0.1	9±0.07	15±0.03
4	19±0.03	10±0.01	9±0.03	16±0.05
5	23±0.05	9±0.05	10±0.08	14±0.07
6	22±0.04	8±0.05	10±0.09	14±0.06

Alkalinity

It is composed primarily of carbonate, bicarbonate and hydroxide in water which tend to elevate the pH of water above 4.5. It represents the buffering capacity of water and its ability to resist changes on pH. Total alkalinity of water is the capacity to react with hydrogen ions. Alkalinity acts as a stabilizer for pH. Alkalinity is also imparted more by the presence of carbon dioxide suggesting the decay of organic matter and is the prominent activity elevating alkalinity in natural water (Sujathe et al, 2011). High alkalinity is a function of ions exchange that is calcium ions are replaced by sodium ions and latter contributed to alkalinity (Sharma et al., 2009).

Das and Chand (2003) recorded low alkalinity during monsoon, which might be due to dilution effect of rainfall. Katariya et al., (1996) have recorded maximum value of alkalinity due to confluence of industrial and domestic wastes. There are many methods of alkalinity generation in the ocean. Perhaps the most well known is the dissolution of $CaCO_3$ (calcium carbonate, which is a component of coral reefs) to form Ca^{2+} and CO_3^{2-} (carbonate). The carbonate ion has the potential to absorb two hydrogen ions. Therefore, it causes a net increase in ocean alkalinity. Calcium carbonate dissolution is an indirect result of ocean acidification. The total alkalinity value of water sample varied from 88ppm to 116 ppm. Maximum total alkalinity was recorded from Manakudy coast during winter season and minimum total alkalinity was recorded from Kanyakumari coast during monsoon season. Except Colachel coast, it was in an increase trend from rainy season to summer season. Total alkalinity did not show any statistically significant spatial and temporal variations in any of the sampling sites. This may be due to the fact that the sampling sites are actually open shore where much fluctuation do not occur.

Table 9. Total Alkalinity (ppm) of seawater from different coasts of Arabian sea in Kanyakumari district. Values expressed are Mean ± SD

Place	Monsoon	Post monsoon	Winter	Summer
1	88±0.12	93±0.1	104±0.06	112±0.04
2	91±0.09	94±0.07	116±0.03	100±0.01
3	93±0.07	96±0.05	100±0.02	108±0.00
4	92±0.02	95±0.06	104±0.04	104±0.05
5	108±0.02	104±0.11	96±0.01	96±0.06
6	90±0.11	93±0.09	100±0.04	112±0.03

Radio Activity

Radioactive pollutants from a nuclear accident can spread from region to region and across the world, resulting in major damage and long-term environmental effects (Balonov, 2007). Spatial and monthly variations of radium isotope concentration in water have been evaluated during oil production in Syria by Al (Masri et al., 2006). The highest average of Ra^{226}, Ra^{228} and Ra^{224} concentration in these samples of water were found to be 41, 37.5 and $1.1Bq^{-1.}$ (Lijana et al., 1996) have measured the radioactivity contamination of surface waters from a fly ash depository at Velenje (Slovenia). The south west coast of the Indian peninsula is a radioactive hotspot with its high activity due to thorium and uranium nuclides as reported from earlier studies (Rajamonickam et al., 2000) along the Manavalakurichi and Midalam coasts in Kanyakumari extended to the Chavara region in Kerala.

In the present study gross alpha and gross beta were counted at different seasons. Among the six coasts, Muttom coast has higher radioactivity in all seasons than other coasts. This may be due to the higher concentration of monazite sand in Muttom and nearby areas. In all coasts minimum activity was recorded in Monsoon and maximum in summer. Minimum gross alpha count was recorded in

Kanyakumari and Manakudy coast in Monsoon season. Similarly minimum gross beta activity was recorded in Thengapattinam coast in Monsoon season. Both gross alpha and gross beta were maximum in Mutton coast. The resulting trend however shows that radiological effect on the living beings is very minimal and bound to have neither health implications nor contributing significant to background radiation.

Table 10a. Gross alpha (BqI^{-1}) of seawater from different coasts of Arabian sea in Kanyakumari district

Place	Monsoon	Post monsoon	Winter	Summer
1	3.1	6.7	6.3	9.1
2	3.5	5.5	6.0	8.1
3	4	5.1	7.4	7.0
4	7.2	9.8	11.6	15.0
5	6,9	6.7	7.9	9.3
6	4.4	5	8.7	8.4

Table 10b. Gross beta (BqI^{-1}) of seawater from different coasts of Arabian sea in Kanyakumari district

Place	Monsoon	Post monsoon	Winter	Summer
1	3.7	3.9	3.9	4.1
2	4.0	4.0	4.3	4.3
3	4.1	4.3	4.4	4.6
4	6.7	7.4	7.5	7.5
5	4.8	4.9	4.9	5.4
6	3.4	3.7	4.0	4.3

Nutrients: Nitrate

Nutrients are considered as one of the most important parameter in the marine environment. Nitrate is considered to be the most stable oxidation level of nitrogen in sea water (Grasshoff et al., 1983). It is identified as the growth limiting nutrient. In most coastal environments, the majority of recycled nitrogen is released from sediments to water in the form of ammonium ion (Kemp et al., 1990). In the present study nitrate concentration did not show much variation in any coast. The concentration varied from 2 g/l to 4 g/l. Nitrate concentration was higher during the winter and the summer season. The highest value is 4 g/l is recorded in all coast except Manakudy. The higher concentration of nitrate in winter and summer in this study region may be mainly from the up welled waters, since the fresh water contribution is not evident.

Table 11. Concentration of Nitrate of seawater from different coasts of Arabian sea in Kanyakumari district

Place	Monsoon	Post monsoon	Winter	Summer
1	2	3	3	4
2	2	2	3	3
3	2	3	4	4
4	3	2	4	4
5	2	3	4	4
6	2	3	3	4

Nutrients: Sulphate

Coastal waters receive large amounts of nutrients from wastewater treatment plants and nonpoint sources. In modernation, nutrient inputs to estuaries and coastal seas can be considered beneficial. They result in increased production of phytoplankton (the microscopic algae floating in water), which in turn can lead to increased production of fish and shellfish (Nixon 1988, Hansson and Rudstam 1990, Rosenberg et al. 1990). However, excess nutrients can be highly damaging, leading to effects such as anoxia and hypoxia from eutrophication, nuisance algal blooms, dieback of sea grasses and corals and reduced populations of fish and shellfish (Smayda 1992). According to Poonam Bhadja et al, 2011 presence of sulphate influenced water quality parameters significantly. In the present study sulphate concentration varied from 1.5 g/l to 4.5 g/l.

Table 12. Concentration of Sulphate of seawater from different coasts of Arabian sea in Kanyakumari district

Place	Monsoon	Post monsoon	Winter	Summer
1	4.5	2.1	1.6	1.9
2	3.7	2.2	1.7	1.7
3	3.4	1.8	1.8	1.5
4	3.2	1.7	1.9	1.7
5	3.7	2	1.8	1.8
6	4.5	2.7	1.6	1.8

High value was recorded during monsoon season from Kanyakumari and Thengapattanam coast which indicates anthropogenically affected water quality status. Low value was recorded during winter and summer season may be due to the absence of inflow of fresh water. The release of sewage and other wastes in the sea could be one of the reasons for this variation. Higher sulphate concentration in Kanyakumari and Thengapattanam indicates a considerable pollution in these sites.

Nutrients: Phosphate

Dissolved Phosphate is the main source for these animals. Fishes gets their phosphorous with the food - in the sea and in the aquarium. If there is too much phosphate in the water animals will die, too. The optimum concentration for sea water is between 0.05 to 0.20 mg/l (ppm) phosphate. Too much phosphate causes a strong growth of green and blue green algae. These algaes are able to grow on the animals and kill them. Even the algae in corals - called zooxanthella - will grow very fast and the corals gets problems. The animal takes out the algae and the animal bleaches. Bleached corals are extremely sensitive and will decease very fast.

Weathering of earth's crust and surface water transport deliver phosphorus to coastal waters through rivers. During the period of active growth of phytoplankton the concentration of phosphorus along with other nutrient salt is readily reduced in aquatic environment. Due to the metabolic activity of living beings, phosphate is regenerated in to the water column from the organic phase. High concentration of phosphate observed during summer season in most of the coastal water may be due to decomposition of particular organic matter (Sukumaran et al., 2013).

Table 13. Concentration of Phosphate of different coasts of Arabian sea in Kanyakumari district

Place	Monsoon	Post monsoon	Winter	Summer
1	0.4	0.4	0.42	1.15
2	0.4	0.5	0.45	0.4
3	0.4	0.52	0.3	0.7
4	0.1	0.15	0.15	1.35
5	0.3	0.3	0.31	0.7
6	0.15	0.23	0.2	0.9

Low concentration of phosphate was recorded in all the seasons except summer may be due to high salinity and utilization of phosphate by phytoplankton (Rajasegar et al., 2002). However, phosphate concentration is higher than the optimum value in all the coasts except Muttom and Thengapattanam which may be due to the intrusion of sea water as well as heavy rainfall, mixing of land run off from agricultural fields contaminated with super phosphates and alkyl phosphates from soap and detergents used by the public for bathing and washing clothes (Senthilkumar et al., 2010).

Conclusions

The water quality of seawater of Chothavilai was almost ideal may be due to the absence of significant anthropogenic load on the coast. The water quality of Kanyakumari,Muttom and Thengapattanam indicates high degree of anthropogenic acivities. Physico-chemical parameters like pH, conductivity, TDS, DO, CO_2, alkalinity and nitrate showed similar variations in almost all the coasts. Turbidity and BOD were higher in Kanyakumari coast suggests the high input of domestic sewage from Kanyakumari town and higher human interference because of tourism. Higher phosphate and radioactivity in Muttom may be due to the fishing harbor and monazite sand in this region. In the present study Chothavilai is considered as the less polluted coast may be due to the minimum human interference and absence of estuary.

Conflict of Interest

Authors declare there are no conflicts of interest.

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