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ASSESSMENT OF SPATIAL VARIATION OF COASTAL WATER QUALITY OF SELECTED BEACHES OF VISAKHAPATNAM COAST, BAY OF BENGAL, INDIA

ANUHYA T, SHARON ROSE A, NIRMALA BHARATHI K, GANESH P. R. C, SIRISHA I R

Department of Marine Living Resources, Andhra University, Visakhapatnam, Andhra Pradesh, India

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ABSTRACT

Study was conducted with the aim to understand the spatial variations of water quality parameters (temperature, salinity, pH, DO, BOD, TSS, TDS, turbidity, conductivity, alkalinity, hardness, NO_3^-, NO_2^-, NH_3-N, PO_4-P, and chlorophyll) in selected beaches *viz.*, Ramakrishna Beach, Varun beach, YMCA beach, Rock beach (Maharanipeta), Sagar Nagar beach and Jalaripeta beach along the coast line of Visakhapatnam in order to assess the health of coastal ecosystem. Statistical analyses were performed using the SPSS statistics software. Pearson's correlation coefficient test was performed to evaluate the relationship between the water parameters. The highest value of temperature (33°C) was recorded at Varun Beach and the lowest value (29°C) at YMCA beach. Total suspended solids varied from 0.04mg/l (Sagar Nagar beach) to 0.36mg/l (YMCA beach). The minimum and maximum values of total dissolved solids of the samples were recorded to be 10.56 mg/l (Rock Beach) to 12.9mg/l (Ramakrishna Beach). The pH ranged from 6.48 (Rock beach) to 7.27 (Ramakrishna beach). The highest salinity (27ppt) was recorded at Ramakrishna beach whereas the lowest salinity (30 ppt) was recorded at Rock beach. The conductivity varied from 15.39 mS/cm (Ramakrishna beach) to 16.39 mS/cm (Sagar Nagar Beach). The Dissolved Oxygen ranged between 3.8mg/l (Varun beach) to 6.1mg/l (Rock beach). The highest BOD (6.1mg/l) was observed at Sagar Nagar beach and the lowest BOD (1.9mg/l) was at YMCA beach. The nitrate values recorded between 0.028 mg/l (Jalaripeta beach) to 0.057mg/l (Varun beach) whereas the nitrite values ranged from 0.0171mg/l (Ramakrishna beach) to 0.0139 mg/l at YMCA beach. The highest values (0.285 mg/l) of ammonia were recorded at Jalaripeta beach and the lowest (0.034mg/l) at Rock beach. The phosphate values ranged from 0.087 mg/l (YMCA beach) to 0.99 mg/l (Jalaripeta beach). The values of total alkalinity were observed to be 50mg /l at Rock beach and 100mg/l at Ramakrishna beach. The minimum (2290 ppm) and maximum (3470 ppm) values of total hardness were observed at Jalaripeta beach and YMCA beach respectively while the total amount of chlorophyll varied from 0.032 µg/l (YMCA beach) to 0.057µg/l (Jalaripeta beach). Generally, the coastal waters of Visakhapatnam show moderate to good water quality, though certain areas experience higher levels of pollution due to industrial discharges, urbanization, and waste dumping. Elevated nutrient levels, in particular, can lead to eutrophication and harmful algal blooms, which may affect both marine biodiversity and local fisheries.

Keywords: *Water quality, Physical, Chemical, Coastal waters, Beaches.*

***Corresponding Author**
P. R. C. Ganesh

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INTRODUCTION

The marine environment is a complex system, mainly influenced by various physical, chemical and biological processes. The open ocean is more stable compared to 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. Physical parameters play an important role in the biochemistry of the water body. Subtle changes in physical conditions can have profound effects on the water quality of the study system, which may in turn affect the spatial and temporal distribution of nutrients and or biological communities. Additionally, changes in physical ocean process can affect weather patterns and climatic variability by Frances Dipper. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen and carbon dioxide. Others are total suspended and dissolved solids, total alkalinity

and acidity and heavy metals contaminated. These parameters are the limiting factors for the survival of aquatic organism (flora and fauna). The physical and chemical properties of water immensely influence the uses of a water body for the distribution and richness of biota and also influence both vertical and horizontal migration of aquatic organisms. It affects their distribution diversity and feeding. The quality 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 parameter and biological characteristics. So, monitoring of these parameters is essential to identify the magnitude and sources of any pollution load.

Sea water quality is a critical aspect of marine ecology, human health and economic activities such as fishing, aquaculture and tourism. The composition of sea water is highly dynamic and influenced by natural processes, such as ocean currents, tides and biological activity, as well as anthropogenic factors, including pollution, coastal development and climate change. Understanding and monitoring water quality parameters in sea water is essential for maintaining marine biodiversity, ensuring the sustainability of marine living resources and mitigating environment degradation. Seawater resources are considered to be one of the major components of environmental resources that are under threat either from over exploitation or pollution, caused by human activities. Coastal area is the most dynamic and productive ecosystems, industry and tourism [1]. Thus, the water quality plays very important role in wellbeing of human, animals and plants inhabiting the area [2]. Surface water quality within a region is influenced by both natural processes and anthropogenic activities [3]. Marine water quality has become a matter of serious concern because of its effects on human health and aquatic ecosystems including marine life [4]. Physico-chemical characteristics are indeed vital water quality parameters for monitoring due to their instability [5], where significant variations in physicochemical parameters affect the quality of water resources.

Visakhapatnam, often referred to as the "Jewel of the East Coast," is one of India's major port cities and an industrial hub with diverse economic activities, including shipping, manufacturing, pharmaceuticals, and petrochemicals. These sectors, while contributing to economic growth, also pose significant threats to water quality due to industrial effluents, untreated sewage, and coastal pollution. Additionally, the city's rapid expansion has led to increased domestic waste discharge, further straining water resources. Given the city's reliance on freshwater sources such as the Meghadrigedda Reservoir and the Gosthani River, as well as its coastal waters along the Bay of Bengal, stringent water quality management is essential. India has established a range of environmental regulations to address water pollution, including the Water (Prevention and Control of Pollution) Act of 1974, the Environment Protection Act of 1986, and various state-level policies. Regulatory bodies such as the Andhra Pradesh Pollution Control Board (APPCB) and the Central Pollution Control Board (CPCB) are responsible for monitoring compliance with these laws. However, the effectiveness of these regulations in Visakhapatnam depends on factors such as regulatory enforcement, technological advancements in wastewater treatment, industrial compliance, and community participation in water conservation efforts.

A number of researchers have studied the physico-chemical as well as water quality parameters of Coastal waters of abroad and India [6-29]. However very few studies on assessing the water quality of coastal waters of Visakhapatnam [30-41].Hence the present study is concentrated on the quality of sea water and also to evaluate and assess the health of coastal ecosystem by analysing the water quality parameters such as temperature, total suspended solids, total dissolved solids, pH, salinity, turbidity, conductivity, dissolved oxygen, biological oxygen demand, nitrate, nitrite, ammonia, phosphate, alkalinity, hardness and chlorophyll.

MATERIAL AND METHODS

Water samples for the analysis were collected from six different sampling stations along the coast line of Visakhapatnam for the study which were the best tourist attractions, include the Rama Krishna (RK) Beach(Station 1, 170 42'53" N; 83019'38" E), Varun Beach (Station 2, 170 42'35" N; 83019'00" E), YMCA Beach (Station 3, 170 43'05" N; 83020'01" E), Rock Beach (Maharani Peta) (Station 4, 170 40'26" N; 83017'36" E), Sagar Nagar Beach (Station 5, 170 45'38" N; 83021'36" E) and Jalaripeta Beach (Station 6, 170 43'98" N; 83019'42" E) (Fig. 1).Surface water temperature of different stations was recorded between mornings to mid noon with the help of thermometer. Samples were collected in separate reagent bottles and analysed at the laboratory for different parameters following standard methods [42]. In case of dissolved oxygen, the collected water samples were fixed with Winkler's A and B separately and further were analysed at the laboratory.

Figure 01: Map showing the sampling stations

RESULTS AND DISCUSSION

Temperature

The temperature of water ranged from 27°C to 28.5°C. The highest value was recorded at Varun beach followed by Sagar Nagar beach and the lowest

value was recorded at Ramakrishna beach. The sea surface temperature ranged from 33°C to 29°C and the highest value (33°C) was recorded at Varun Beach and the lowest value (29°C)at YMCA beach(Fig. 2)

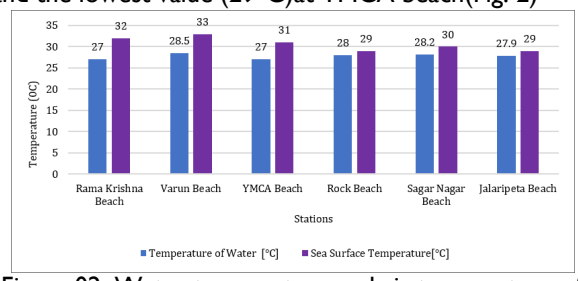

Figure 02: Water temperature and air temperature of samples

Total Suspended Solids

Total suspended solids of samples ranged from 0.04mg/l to 0.36mg/l and the highest range of the suspended solids present at station 5 *i.e.* Sagar Nagar with 0.36mg/l and the lowest range of suspended solids present in station 3 *i.e.* YMCA beach.

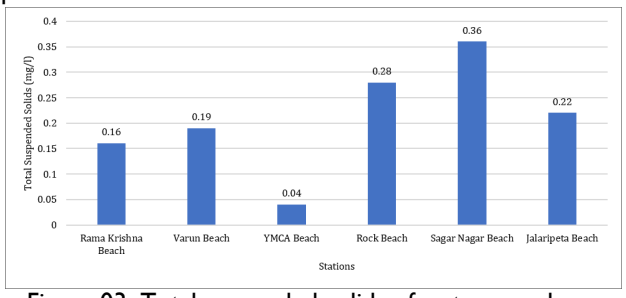

Figure 03: Total suspended solids of water samples

Total Dissolved Solids (TDS)

The dissolved solids of samples ranged from 10.56 mg/l to 12.9mg/l. The highest highest value was recorded at Rock beach and the lowest value at Ramakrishna beach.

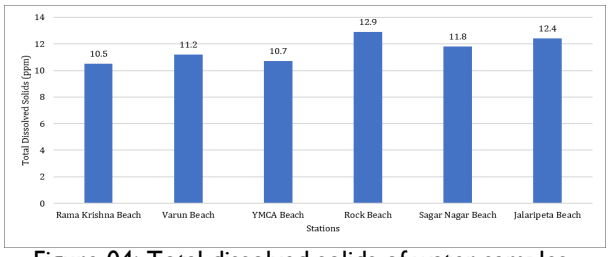

Figure 04: Total dissolved solids of water samples

pH

The pH of the samples collected ranged from 6.48 to 7.27. The highest value was recorded at station 1 *i.e.* Ramakrishna beach with 7.27 and the lowest value was recorded at station 4 *i.e.* Rock beach with 6.48.

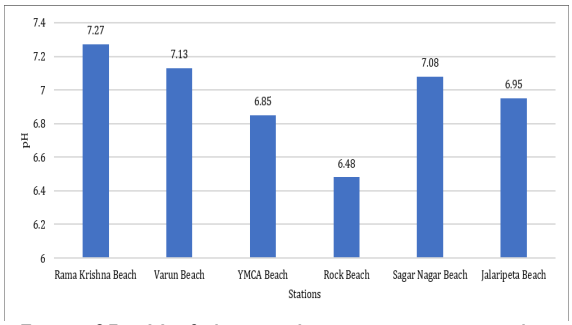

Figure 05: pH of clean and sewage water samples

Salinity

The salinity values were recorded between 27ppt to 30ppt. The highest value of the salinity was recorded at station 1 *i.e.* Ramakrishna beach and the lowest value recorded at station 4 *i.e.* Rock beach.

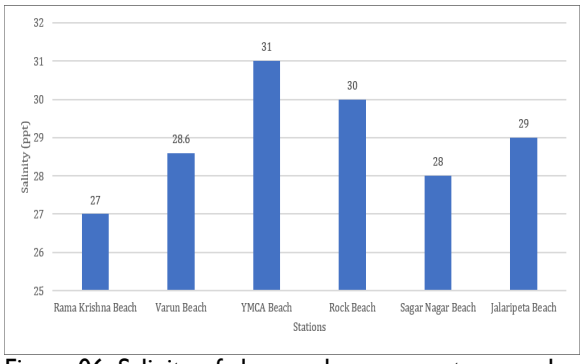

Figure 06: Salinity of clean and sewage water samples

Conductivity

The conductivity of water samples ranged from 15.39mS/cm to 16.39mS/cm. The highest value (16.39mS/cm) was recorded at station 1 *i.e.* Ramakrishna beach whereas the lowest value (15.39mS/cm) at station 5 *i.e.* Sagar Nagar Beach.

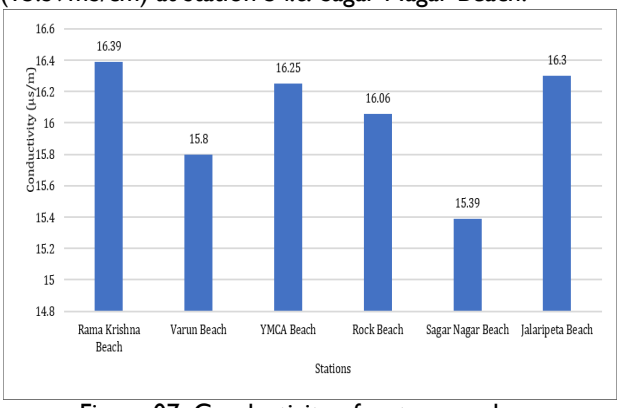

Figure 07: Conductivity of water samples

Dissolved oxygen/ Biological Oxygen Demand

The DO of water samples ranged from 3.8mg/l to 6.1mg/l. The highest DO was recorded at station 4 *i.e.* Rock reach (6.1mg/l) whereas the lowest DO (3.8mg/l) was at station 2 *i.e.* Varun beach. The BOD values of water samples ranged from 1.9mg/l to 4.4mg/l, the highest BOD was recorded at station 5 *i.e.* Sagar Nagar with 6.1mg/l and the lowest BOD was at station 3 *i.e.* YMCA beach with 1.9mg/l.

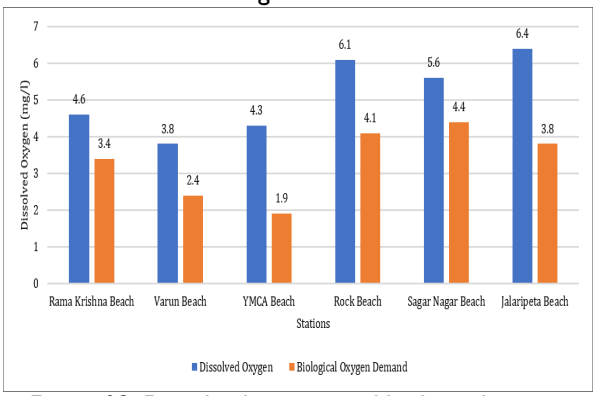

Figure 08: Dissolved oxygen and biological oxygen demand of water samples

Nitrate

The Nitrate values of water samples were recorded between 0.028 mg/l to 0.057mg/l. The highest nitrate levels was recorded at station 2 *i.e.* Varun beach with 0.057mg/l and lowest nitrate levels recorded was 0.028 mg/l at station 6 *i.e.* Jalaripeta beach.

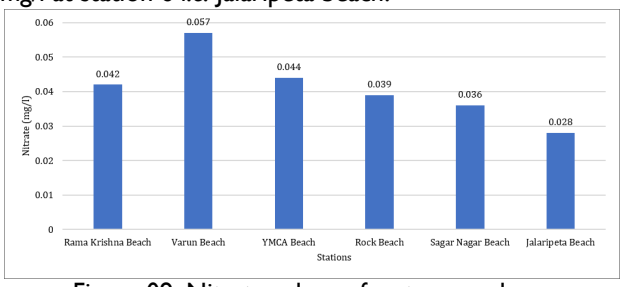

Figure 09: Nitrate values of water samples

Nitrite

The Nitrite of water samples ranged between 0.0139mg/l to 0.0171 mg/l. The highest value was observed at station 1 *i.e.* Ramakrishna beach and the lowest value observed at station 3 i.e. YMCA beach.

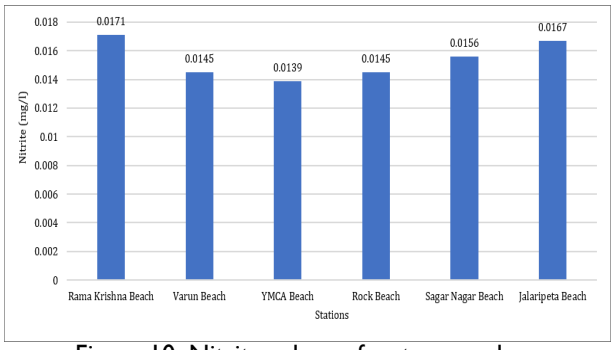

Figure 10: Nitrite values of water samples

Ammonia

The Ammonia content present in the collected water samples at different stations ranged between 0.034 mg/l to 0.285 mg/l. The highest (0.285 mg/l) at station 6 *i.e.* Jalaripeta and the lowest (0.034mg/l) ammonia content at station 4 *i.e.* Rock beach.

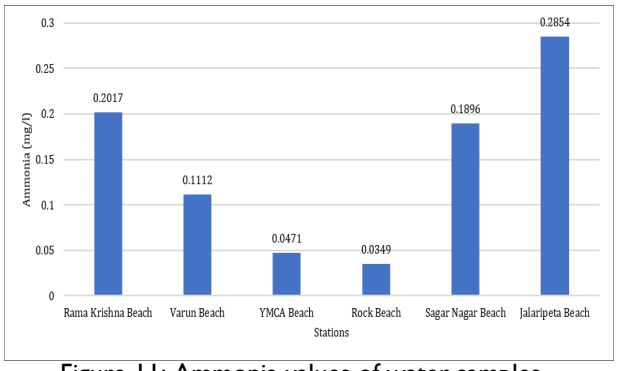

Figure 11: Ammonia values of water samples

Phosphate

The Phosphate present in the water samples collected ranged from 0.087 mg/l to 0.99 mg/l. The highest value of 0.99 mg/l was recorded at station 1 *i.e.* Jalaripeta whereas the lowest phosphate content of 0.087 mg/l was recorded at station 3 *i.e.* YMCA beach.

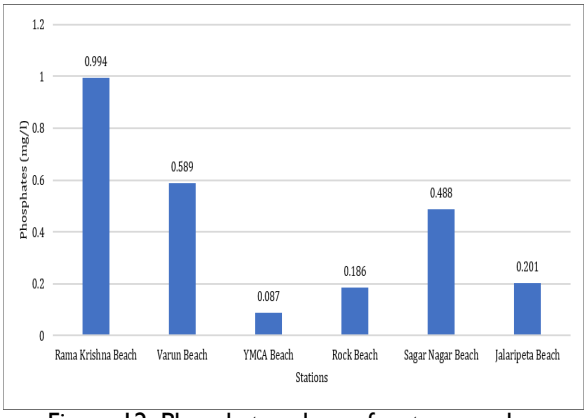

Figure 12: Phosphate values of water samples

Alkalinity

The total alkalinity observed in the water samples ranged between 50mg /l to 100mg/l. The highest value was observed at station 1 *i.e.* Ramakrishna beach whereas the lowest value at station 4 *i.e.* Rock beach.

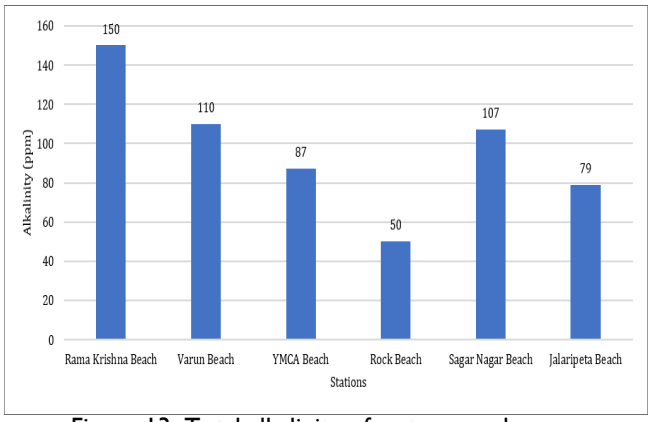

Figure 13: Total alkalinity of water samples

Hardness

The total hardness content present in the water samples was between 2290 ppm to 3470 ppm. The maximum value was recorded at station 6 *i.e.* Jalaripetta whereas the minimum value was recorded at station 3 *i.e.* YMCA beach.

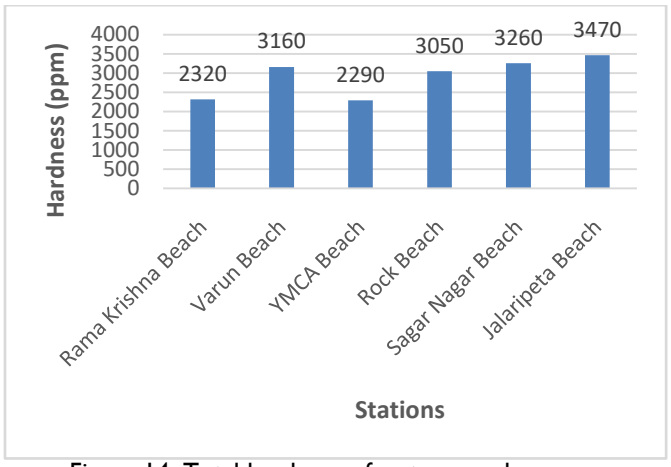

Figure 14: Total hardness of water samples

Chlorophyll

The total amount of chlorophyll recorded in the water sample ranged between 0.032 µg/l to 0.057µg / l. The

highest value was observed at station 6 *i.e.* Jalaripeta whereas the lowest value was recorded at Sagar Nagar beach.

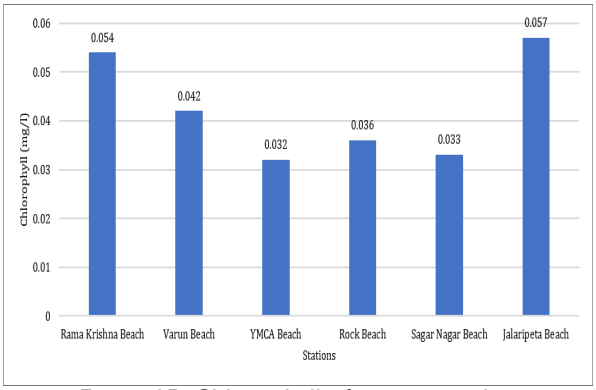

Figure 15: Chlorophyll of water samples

Sea water temperature is an important parameter for the physical and biochemical processes occurring within water as well as in air-water interactions because temperature regulates physical, chemical, and biological processes in water. Water temperature also influences the solubility and thus availability of various chemical constituents in water. Most importantly, this parameter affects dissolved oxygen concentrations in water; as oxygen solubility decreases with increasing water temperature. It is also very important to analyse the temporal variations due to seasonal changes. On the other hand, distribution, transportation, and interaction of some contaminants, such as nutrients have a significant relation with water column temperature. The highest temperature value recorded was 33°C from station 2 (Varun Beach).

The TSS concentration is constantly associated with heavy rainfall followed by high discharge at the river mouth of Rushikulya. Higher TSS values during the monsoon are apparent in Bay of Bengal due to increased river discharge and runoff. This sediment-rich water then flows into the coastal areas, elevating TSS levels. However, the highest TSS value during monsoon followed by post-monsoon during 2013 near Rushikulya mouth is attributed to high monsoonal rainfall during monsoon and the cyclone Phailin during October, 2013. During July, 2013, floating materials like fine silt and detritus carried by rainwater from the catchment resulted in higher TSS values (745 mg/l) at mouth region. Besides, during the period 2008–2011, high TSS is observed at the Port area significantly because of dredging and construction activities near its vicinity [39]. However, TSS concentration was extremely low at every station in July and August of 2012, even though, there was intense rainfall. Due to infrequent event-based sampling, a snapshot of TSS levels at one point in time was available while the sampling method missed the peak TSS episodes. Particularly higher TSS values at the river mouth as compared to the other two sectors could be due to river influx and tidal mixing. The highest range of the suspended solids present in station 5 *i.e.* Sagar Nagar with 0.36mg/l.

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 [43]. 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 [29]. The pH of water is important because many biological activities can occur only within narrow range [29]. 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 CO2 by photosynthesis through bicarbonate degradation of water with fresh water influx, reduction in salinity and temperature and decomposition of organic matter [43]. Due to the seasonal changes and ocean acidification the highest range of the pH value recorded is in station 1 *i.e.* Ramakrishna beach with 7.27 mg/L, the range decreased when compared with the above scenario.

Salinity is another important factor which influences the distribution of organisms. The salinity at any point will be dependent on the rainfall and extent of freshwater inflow. In the current evaluation, the post-Hudhud observations have indicated significant decline of salinity in all the three stations. A typical pattern of salinity was observed in the coastal waters of Visakhapatnam with high values of salinity in summer and low values during December. These low values could be attributed to strong southerly surface current that is known to bring large quantities of freshwater during south-west. Due to surface water currents the range of salinity was measured; the highest range of the salinity present in station 1 *i.e.* Ramakrishna beach with 30ppt.

In Visakhapatnam, electrical conductivity typically ranges between 40–50 mS/cm (milli Siemens per centimetre) for normal seawater, depending on the salinity levels, seasonal changes, and pollution load. This value is in line with coastal regions where seawater salinity and ion concentration are relatively stable. However, localized areas, especially near industrial zones or river mouths, may experience higher conductivity levels due to increased ion concentration from pollution or runoff. Electrical conductivity in the coastal waters of Visakhapatnam is an important parameter for assessing water quality, particularly in terms of salinity and pollution levels. The concentrations of dissolved ions are influenced by various natural and anthropogenic factors, including river runoff, industrial discharges, and seasonal variations. Elevated conductivity levels often indicate pollution, which can adversely affect marine organisms

and the broader ecosystem. The reason for the decreasing range due to low pollution and the concentration of dissolved ions are less. The highest range of conductivity can be seen in station 1 *i.e.* Ramakrishna beach which has a range of 16.39mS/cm.

DO is essential to the metabolism of all aquatic organisms that possess aerobic respiratory biochemistry and the maximum oxygen requirement for fish life is 3mg/L [37]. Low DO concentration threats the survival of aquatic organisms except anaerobic microbes [38]. DO could be attributed due to the entry of untreated sewage and other organic wastes in to the water body [39]. 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 [40, 41]. 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. Higher DO observed during post monsoon and winter might be due to the heavy rain fall, fresh water mixing and higher wind energy. The observed DO was above 5 mg/l which is also reported earlier in the Arabian Sea [26]. 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 [39]. The inverse relationship between temperature and DO is a natural process [38]. As the temperature influences DO in the study area the temperature recorded was 27 to 30°C which gives more DO concentration. The DO values of our study area were 3.8mg /l to 6.1 mg/l.

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 [33]. Water bodies with BOD value exceeding 8 mg/l have been regarded as moderately polluted [37]. 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 [38]. With the DO level beyond 5 mg/l level the BOD and COD would be minimum which was observed in this study [39]. 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 a smaller number of biodegradable pollutants in these coasts. Due to biodegradable pollutants the highest values of BOD are recorded at YMCA beach (4.4 mg/l)

Nutrients are considered as one of the most important parameters in the marine environment. Nitrate is considered to be the most stable oxidation level of nitrogen in sea water [33]. 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 [39]. 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. When observed at our stations the sediment concentration and due to seasonal changes, the nitrate is observed to be low i.e. 0.057mg/l because of post monsoonal sample collection, the concentration of nitrites is observed to be low i.e. 0.0171 mg/l.

Ammonia concentration was varied from 0.700 μ mol/L to 38.409 μ mol/L. Minimum ammonia concentration was recorded during October 2006 at station 4 and maximum was recorded during March 2007 at station 1. The high values of ammonia observed in all the stations except station 4 may be attributed to the raw sewage and effluents entering here. The land runoff plays a major role in the enrichment of ammonia. As there was no land runoff in the station the ammonia ranges are very low and the highest value was observed at our station Jalari Peta with 0.285 mg/l.

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 algae's are able to grow on the animals and kill them. Even the algae in corals - called zooxanthella - will grow very fast and the corals get problems. 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 [23]. Low concentration of phosphate was recorded in all the seasons except summer may be due to high salinity and utilization of phosphate by phytoplankton [36]. Due to intrusion of seawater as well as heavy rainfall the phosphate levels are raised in the Ramakrishna beach with 0.99mg/l.

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. High alkalinity is a function of ions exchange that is calcium ions are replaced by sodium ions and latter contributed to alkalinity [21]. There are many methods of alkalinity generation in the ocean. Perhaps the most well-known is the dissolution of CaCO3 (calcium carbonate, which is a component of coral reefs) to form Ca2+ and CO32− (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 88 ppm 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. As the pH increases, alkalinity increases and due to decaying of more organic matter in Ramakrishna beach with 150 mg/l.

Seawater hardness generally falls within the typical range for coastal regions, with values between 5800 mg/L and 7500 mg/L as $CaCO_3$. However, variations can be observed depending on seasonal changes, industrial activity, and freshwater inputs. During the monsoon season, increased runoff may cause a slight dilution of seawater, lowering the hardness temporarily, while during dry periods, evaporation can increase the concentration of hardness-inducing ions. In particular, the inner bays of Visakhapatnam may show higher fluctuations in hardness due to the influence of freshwater from rivers and the higher presence of anthropogenic pollutants and also the seasonal changes, the highest value recorded at the Ramakrishna beach with 3160mg/l.

Chlorophyll concentration revealed wide seasonal variation. Chlorophyll-a varied from 1.35 to 6.92, 1.54 to 7.41 and 0.99 to 2.47 mg/m3 for pre-monsoon, post monsoon and summer seasons respectively. Relatively, higher values are also observed during post monsoon season reflects the higher phytoplankton productivity. The variation of Chlorophyll content during post monsoon is insignificant and a reverse condition is marked during pre-monsoon season. The chlorophyll concentration was observed higher during post monsoons.

The concentrations of chlorophyll and phaeopigments in Visakhapatnam's coastal waters provide valuable insight into the biological productivity and health of the marine environment. Chlorophyll reflects active photosynthetic processes, indicating productive waters, while phaeopigments provide information about organic matter decomposition and potential eutrophication. The interplay between these two pigments is crucial for understanding the impacts of nutrient loading, pollution, and seasonal variations on the coastal ecosystem, the highest values recorded in Jalaripetta with 0.057µg/l and phaeo pigments recorded as 2.7 µg/l in station Sagar Nagar beach.

CONCLUSION

The major objectives of this study were to study about the spatial variations of water quality of Sea water parameters. The present study is tried to discuss basically what water pollution is and focused on different causes of water pollution, effects of this pollution on Earth. This study is based on secondary sources of data from different government reports, research articles, journals and books, internet sources and from the report of Andhra Pradesh state pollution control board (APPCB). In the study area water pollution is mainly increased due to over population, agricultural practices, soil erosion, industrialization and urbanization. Water is life for all but this water is polluting day by day in severe condition. So, it can be said that our life (water) is not safe now. We are in crisis period. Water pollution is a major serious problem for all over the world. It affects drinking water, rivers, lakes and oceans all over the world. It consequently harms the health and wellbeing of human life and the natural environment. It is impossible to substitute for most of its uses, difficult to de pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable natural resources as it is capable of diversion, transport, storage, and recycling. All these properties impart to water its great utility for human beings. The surface water and groundwater resources of the country play a major role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, recreational activities etc. In conclusion, the physico-chemical parameters of coastal waters in Visakhapatnam play a crucial role in determining the overall health of the marine ecosystem. Parameters such as temperature, pH, salinity, dissolved oxygen, turbidity, and nutrient concentrations (e.g., nitrate, phosphate, and silicate) are essential indicators of water quality and marine life sustainability. The variations in these parameters are influenced by factors like seasonal changes, industrial activities, coastal erosion, and human pollution. Generally, the coastal waters of Visakhapatnam show moderate to good water quality, though certain areas experience higher levels of pollution due to industrial discharges, urbanization, and waste dumping. Elevated nutrient levels, in particular, can lead to eutrophication and harmful algal blooms, which may affect both marine biodiversity and local fisheries. To ensure the continued sustainability of these coastal ecosystems, regular monitoring of physico-chemical parameters is essential. Furthermore, implementing effective management strategies to control pollution and reduce human impact is critical for the preservation of marine

resources and the health of the coastal environment in Visakhapatnam.

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