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Research Article

Studies on Water Quality Parameters of Vasistha Godavari Estuary, East Coast of Andhra Pradesh, India

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ABSTRACT

A 30 km stretch of the lower Vasistha Godavari Estuary (Between 16º18'26"N,81º42'57"E; 16º28'58"N 81º50'30"E) was surveyed during October 2016 – June 2017 to study the various water quality parameters like Temperature, pH, Salinity, D.O. Alkalinity, B.O.D and TAN by taking samples at three stretches (locations). (L1=Antervedi; L2= Narsapur; and L3=Chinchinada). The two way ANOVA results shows that, there is significant relationship between the Temperature, pH, Salinity, D.O. B.O.D. Alkalinity, Nitrite, Nitrate and TAN across the time periods. The results also shows that there is No significant relationship between the Temperature, pH, Salinity, D.O. B.O.D. Alkalinity, Nitrite, Nitrate and TAN across three locations, Based on the present study it is observed that the study area have high potential for brackish water shrimp culture development based on values obtained which were in conformity with recommended values for shrimp culture.

Keywords: *Water Quality Parameters, Vasistha Godavari Estuary, Brackishwater Aquaculture, Effluents*

INTRODUCTION

Aquaculture has become important sources of food, nutrition, income and livelihood of hundreds of millions of people around the world. Andhra Pradesh contributes nearly 40 per cent of the total marine exports of the country. Shrimp farming is highly resilient in West Godavari region (Srinivas et al., 2016). An Estuary, where a river meets the sea provides high level nutrients both in water column and in sediment, making estuaries among the most productive natural habitat for brackish water aquaculture (Simpson et al., 2001) and are considered to be excellent natural nursery grounds for a variety of fish and shrimp (Kimirei et al., 2011; Minello et al., 2003; & Dorenbosch et al., 2005). The River Godavari is India's second longest river after the Ganga. At Dowaleswaram (16°56'59.99" N 81°44'59.99" E) it braches into two main distributaries called Vasistha Godavari and Gowthami Godavari. The two distributaries together constitute the second biggest river-estuarine system along the east coast of India.

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The present study focus on Vasistha Godavari Estuary (VGE). In this region, Vasistha Godavari Estuary is the source of water for both inlet and outlet for aquaculture farms. Effluents discharges from shrimp farms is the major source of pollution (Boyd, 2003; Pham et al., 2010; & Bui et al., 2012**)** in this region. Due to this problem aquaculture farmers are slowly shifting from brackish water (inexpensive & readily available) area to fresh water area, which needs to be controlled. Hence the study is undertaken to bring awareness among the farmers on suitability of Vasistha Godavari Estuary (VGE) water for shrimp culture, so that, the farmers in this region, may not to resort to fresh water areas.

Water quality is the most important factor affecting fish/shrimp health and performance in aquaculture production systems. Different fish/shrimp species have different and specific range of water quality aspects (temperature, pH, oxygen concentration, salinity, etc.) within which they can survive, grow and reproduce. Outside these optimum ranges, fish/shrimp will exhibit poor growth, erratic behaviour, and disease symptoms or parasite infestations.

Therefore the main objective of this study is to assess the water quality parameters of Vasistha Godavari estuarine waters and to find out the suitability of these waters for brackish water aquaculture.

MATERIALS AND METHODS

2.1. Study Area:

The Study area, Vasistha Godavari (VG), western distributary of Godavari estuarine system, flows about 90 km from Dowaleswaram emptying into the Bay of Bengal at Antervedi (16.3227° N, 81.7303° E) .The average width of Vasistha Godavari(900 m) was significantly less compared to Gowthami Godavari (1200m). So less volume (23 %) of fresh water discharge enter into the study area. Due to lesser width, low discharge of fresh water, VG was appeared geo morphologically as wave dominated estuary. Like other monsoon-fed Indian estuaries, it has an annual flood phase between July and September (SW monsoon period).The rest of the year can be divided into a recovery or post monsoon phase of highly fluctuating low salinities (October to December), a stable phase of moderate salinities with typical estuarine conditions (January to March) and a drought or pre monsoon phase of total marine domination (April to June).

Based on seasonality of brackish water and based on water source, Seasonal culture, Tide dependent culture and Pump dependent cultures are being practiced in this region (VGE). However, there are three usual Farm Periods (FP) in this region, they are FP-1.August-September-October; FP-2. January-February-March; FP-3. April-May-June; Coinciding with annual flood phase, stable phase of moderate salinities, and drought phase of total marine domination respectively. Observations were done in correlation with farm periods in this estuary. i.e. October 2016-Monsoon with FP-1 discharge; January 2017-Post Monsoon-Stable phase with FP-2 beginning; June 2017-Pre Monsoon-Drought phase with FP-3 discharge.

Fig. 1: Study Area showing Three Locations

2.2. Description of the Sampling sites

The water samples were collected from three different locations of VGE from Oct 2016-June 2017. The sampling locations are as follows:

Location.1 (L-1):

The geographical coordinates of Antervedi (L-1) is 16º 20′46″ N, 81º43′16″E and it is about 2 km from the mouth towards head, where intense aquaculture activities are being practiced.

Location.2 (L-2):

The geographical coordinates of Narsapur (Lacation-2) is 16º24′45″N,81º42′05″E and it is about 15 km from the mouth towards head, where intense aquaculture activities are being practiced.

Location 3 (L-3):

The geographical coordinates of Chinchinada (Location-3) is 16º26′29″N, 81º46′35″E and about 25 km from the mouth towards head, where intense aquaculture activities are being practiced.

2.3. Collection and preservation of samples

Water samples were collected from surface (< 1m) and bottom (~ 5 or 10m, based on column depth) by using Niskin Sampler at three locations, where aquaculture effluents (Pond waters) are usually drained out. The water samples were collected in seasonal intervals in correlation with the aquaculture farm periods from October 2016 to June 2017.The water samples were collected in pre-cleaned polyethylene bottles(except for DO and BOD) and stored in ice boxes and brought to the laboratory.

2.4. Water quality variables:

Water quality variables were determined by following standard methods (APHA, 1995).

2.5. Methods of water sampling analysis:

2.5.1. Temperature:

Temperature was measured with a calibrated clean thermometer (±0.1°C) put in the Niskin sampler by opening its lid. While taking the reading, the thermometer should be immersed in water for one minute and up to the level of mercury in the capillary column. Temperature was expressed as degrees Celsius (^{0}C).

2.5.2. pH:

pH was measured on Thermo Scientific Orion Star bench top pH meter with accuracy of ±0.01.While taking the reading the probe was dipped in water sample, wait until the standard reading without fluctuation and note down the reading displayed on the display.

2.5.3. Salinity:

Salinity was determined by Mohr-Knudsen argentometric titration method. 5 ml of sample taken into clean conical flask add 6 drops of potassium chromate indicator and titrate with silver nitrate solution while stirring vigorously on magnetic stirrer and continue the titration until colour changes from yellow to dirty orange.

2.5.4 Dissolved oxygen:

Dissolved oxygen was fixed with Winkler's reagents onboard and determined by titrimetric method in the laboratory. Add 3 ml of 50% hydrochloric acid, by inserting the pipette tip close to the settled precipitate in DO bottle, Stopper the bottle immediately and shake vigorously till all the precipitate dissolves. Pipette out 50 ml of the clear solution in a conical flask and titrate against thiosulphate solution from the burette using starch as an indicator.

2.5.5. Biological Oxygen Demand:

Keep the sampled bottles in the BOD incubator at 27ºC for 5 days. Determine DO of sample collected separately using Winkler method and record the value obtained as "Initial DO". Remove the BOD samples from the incubator and analyze DO as per procedure and record the values as "Final DO". Finally subtract final DO from initial DO.

2.5.6. Alkalinity:

Alkalinity was measured following titrimetric method.10 ml of water sample is taken into conical flask and to it 2 drops of phenolphthalein indicator is added. Titrate with 0.02N sulphuric acid until the color change from pale pink to colorless, note down the readings. Again 5 drop of methyl orange or methyl red indicator is added to that solution, titrated with 0.02 N Sulphuric acid until the color change from yellow to pink.

2.5.7. Total Ammonia Nitrogen (TAN):

Total ammonia nitrogen (TAN) was determined using spectrophotometric method (APHA, 1995).

2.5.8. Nitrite:

Water samples were filtered through GF/F filters. Those filtered samples were used for the determination of Nitrite by standard spectroscopic method (APHA, 1995).

2.5.9. Nitrate:

Water samples were filtered through GF/F filters. Those filtered samples were used for the determination of Nitrate by standard spectroscopic method (APHA, 1995).

2.6. Statistical analysis:

Data were statistically analysed and comparison among different locations was done by Two-way analysis of variance (ANOVA) to find out any significant ($P<0.01$) difference among the results was done using Statistical Package for Social Sciences (SPSS; 16.0 version).

RESULTS

***3.1. Temperature*:**

The temperature was found to be vary in different seasons in different locations of the study period was ranged from 27ºC to 34ºC for surface; 25.5ºC to 33ºC for bottom. The mean values of temperature during the study period were presented in fig.2.

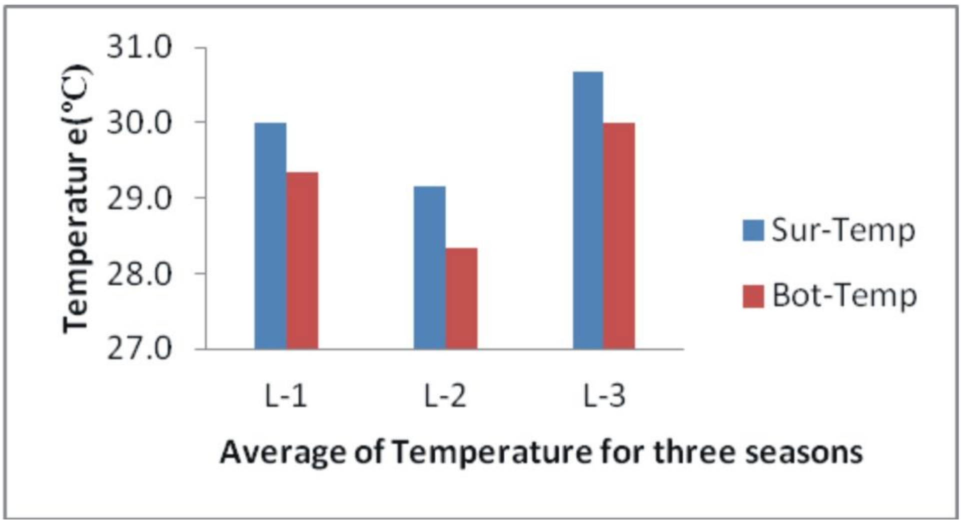


Fig. 2: Mean values of Temperature during the study period

3.2. pH:

The pH was found to be varying in different seasons in different locations of the study period was ranged from 7.78 to 8.47 for surface; 7.76 to 8.26 for bottom. The mean values of pH during the study period were presented in fig.3.

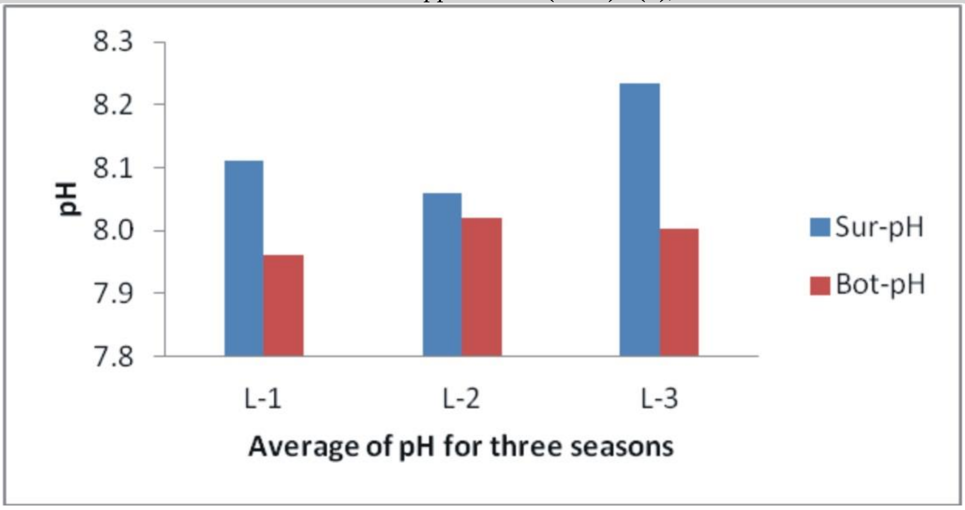


Fig. 3: Mean values of pH during the study period

3.3. Salinity:

The pH was found to be varying in different seasons in different locations of the study period was ranged from 0.60 ppt to 29.58 ppt for surface; 4.41 ppt to 34.44 ppt for bottom. The mean values of Salinity during the study period were presented in fig.4

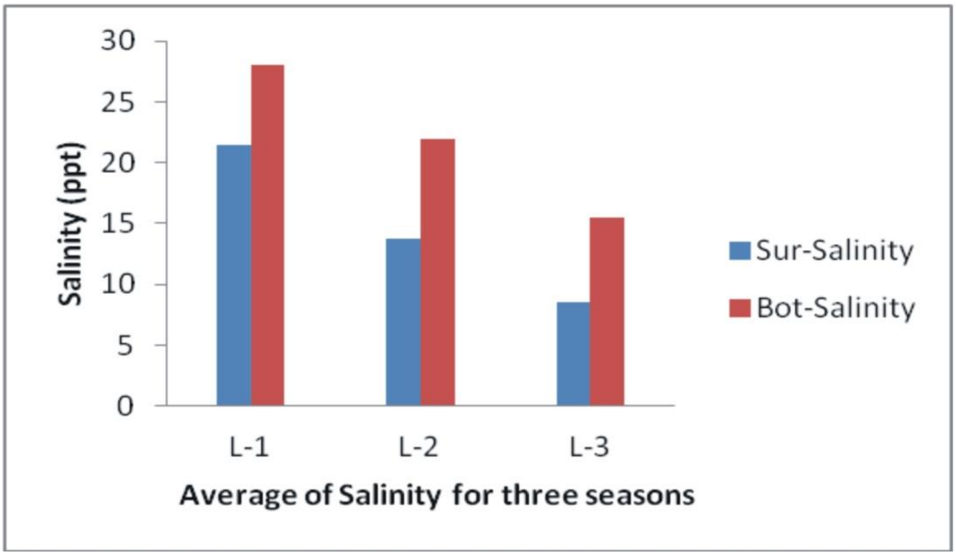


Fig. 4: Mean values of Salinity during the study period

3.4. Dissolved Oxygen:

The Dissolved Oxygen was found to be varying in different seasons in different locations of the study period was ranged from 5.99 mg/L to 8.56 mg/L for surface; 4.48 mg/L to 8.40 mg/L for bottom. The mean values of dissolved oxygen during the study period were presented in fig.5

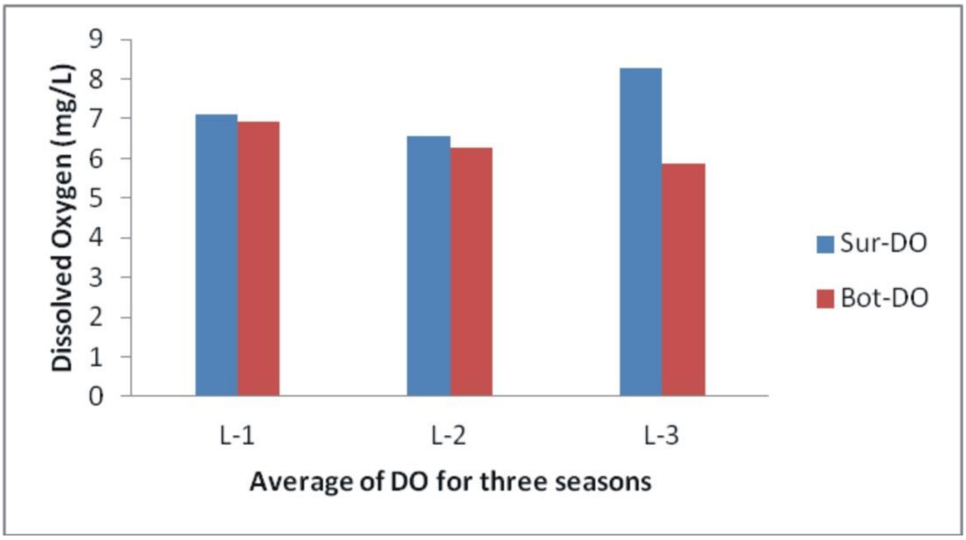


Fig. 5: Mean values of Dissolved Oxygen during the study period

3.5. Biological Oxygen Demand:

The Biological Oxygen Demand (BOD) was found to be varying in different seasons in different locations of the study period was ranged from 0.32 mg/L 2.40 mg/L for surface; 0.53 mg/L to 2.24 mg/L for bottom. The mean values of biological oxygen demand during the study period were presented in fig.6.

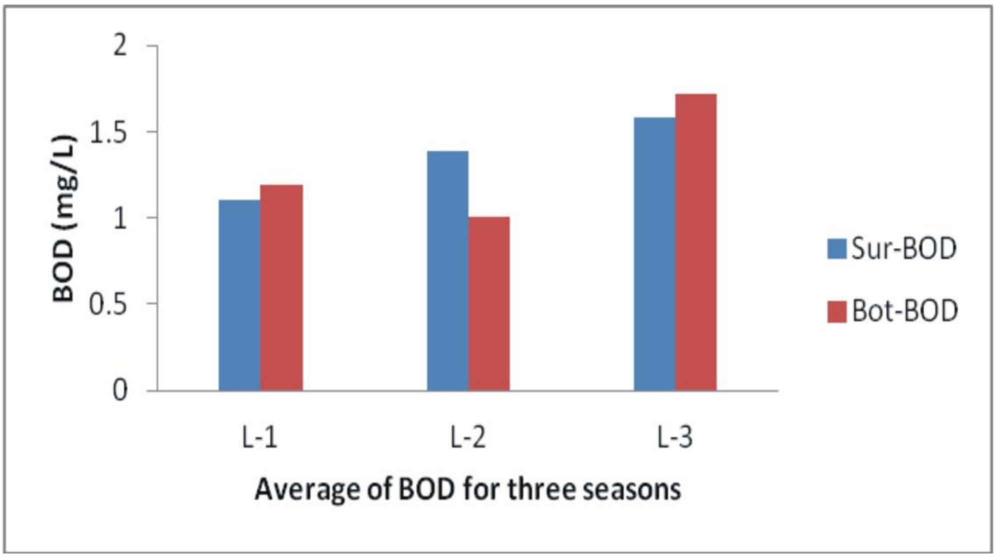


Fig. 6: Mean values of biological oxygen demand during the study period

3.6. Nitrite:

The Concentration of Nitrite was found to be varying in different seasons in different locations of the study period was ranged from 0.003 mg/L to 0.05 mg/L for surface; 0.02 mg/L to 0.41 mg/L for bottom. The mean values of Nitrite during the study period were presented in fig.7.

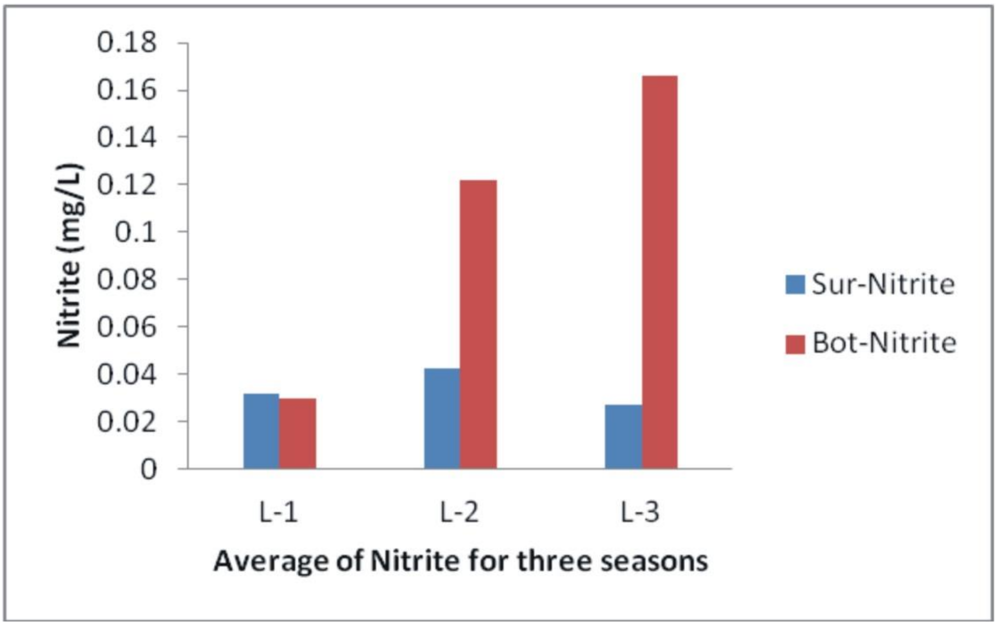


Fig. 7: Mean values of Nitrite during the study period

3.7. Nitrate:

The Concentration of Nitrate was found to be varying in different seasons in different locations of the study period was ranged from 0.28 mg/L to 2.57 mg/L for surface; 0.24 mg/L to 1.97 mg/L for bottom. The mean values of Nitrate during the study period were presented in fig.8

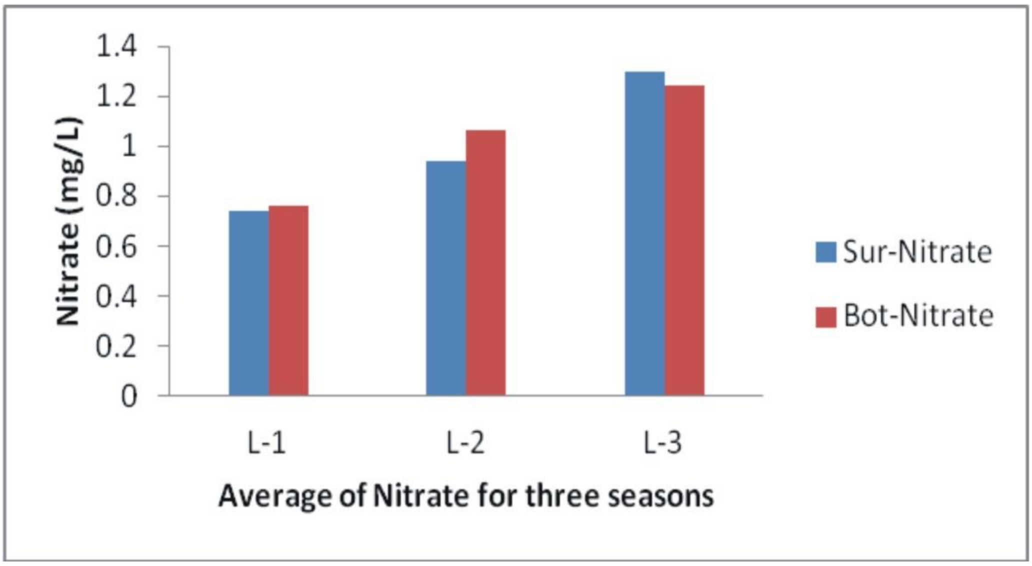


Fig. 8: Mean values of Nitrate during the study period

3.8. Total Ammonia Nitrogen:

The concentration of Total Ammonia Nitrogen (TAN) was found to be varying in different seasons in different locations of the study period was ranged from 0.127 mg/L to 0.128 mg/L for surface; 0.127 mg/L to 0.128 mg/L for bottom. The mean values of TAN during the study period were presented in fig.9.

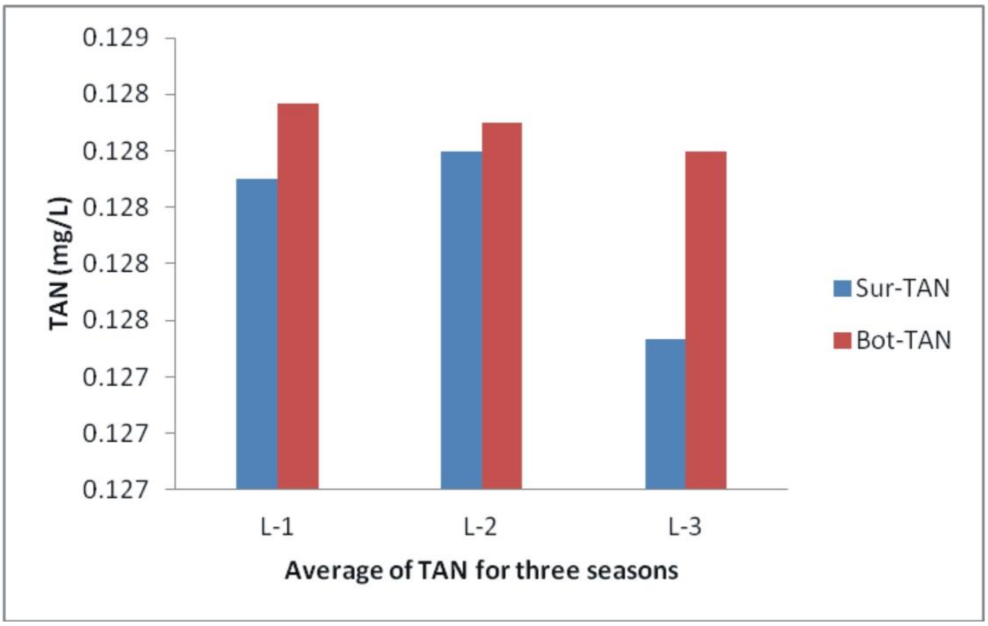


Fig. 9: Mean values of TAN during the study period

3.9. Alkalinity:

The concentration of alkalinity was found to be varying in different seasons in different locations of the study period was ranged from 105 mg/L to 182 mg/L for surface; 102 mg/L to 178 mg/L for bottom. The mean values of alkalinity during the study period were presented in fig.10.

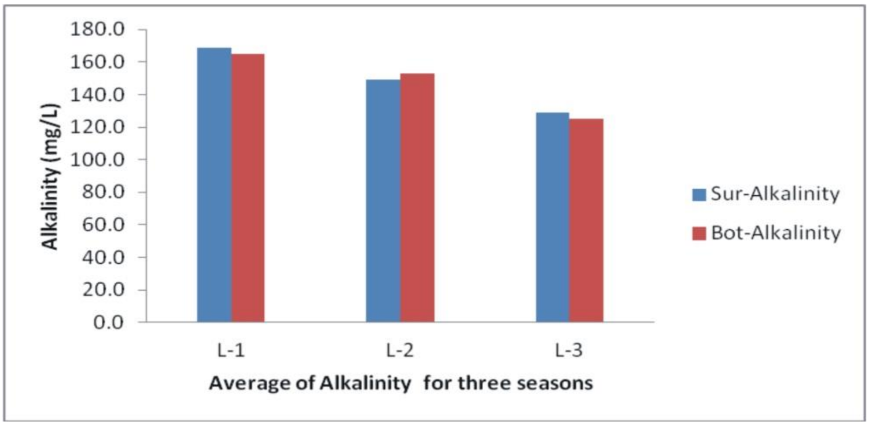


Fig. 10: Mean values of alkalinity during the study period

Surface and bottom values of various parameters of three locations in three seasons are presented in fig.11.1 to 11.27

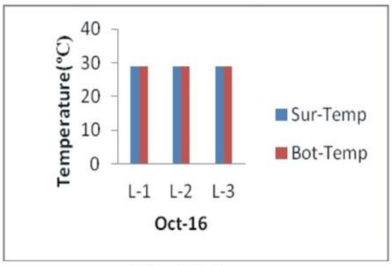


Fig. 11.1

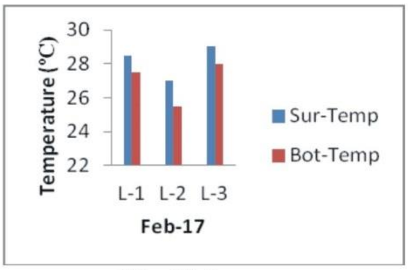


Fig. 11.2

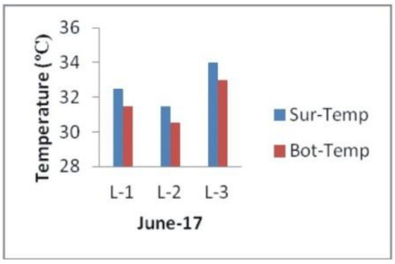


Fig. 11.3

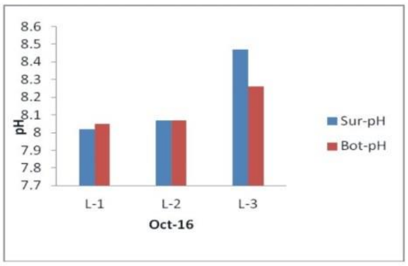


Fig. 11.4

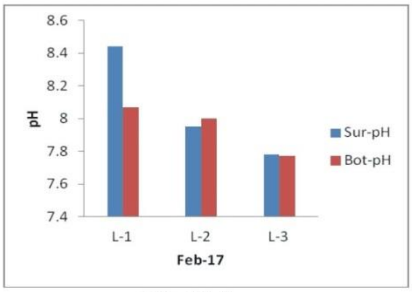
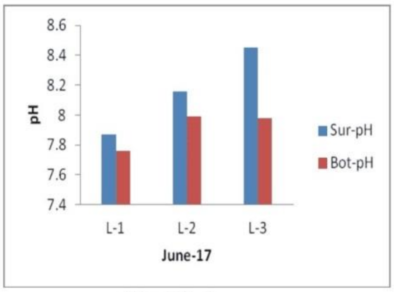


Fig.11.5



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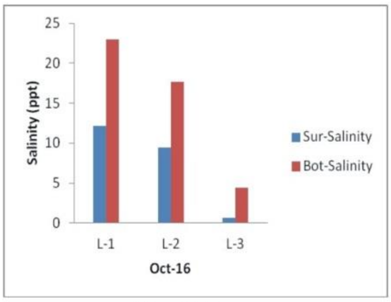

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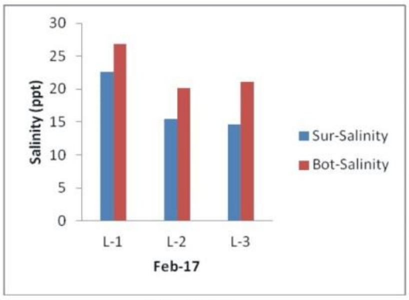

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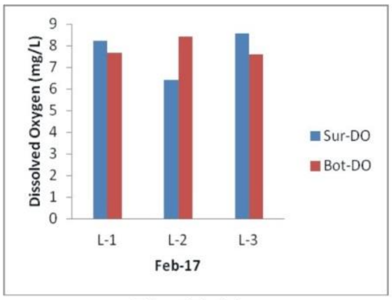
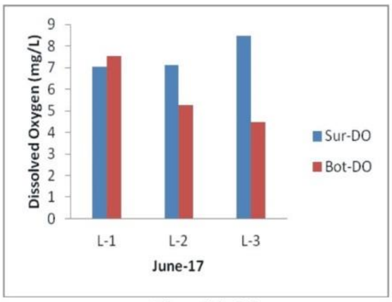


Fig. 11.11



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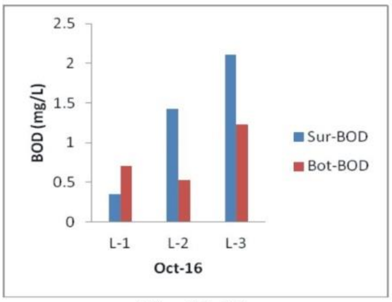

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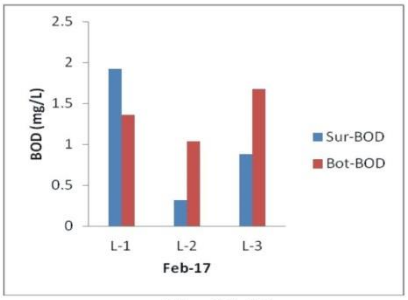

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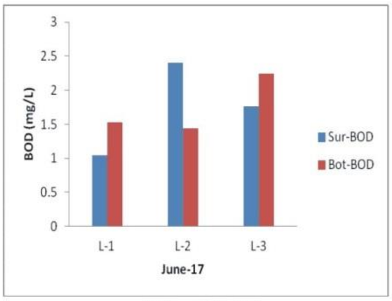

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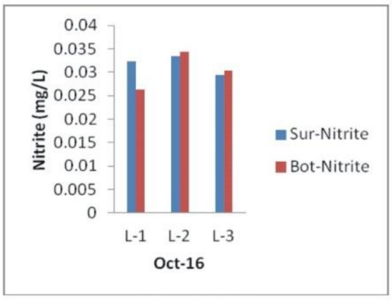

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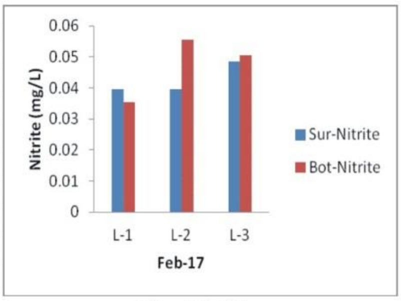

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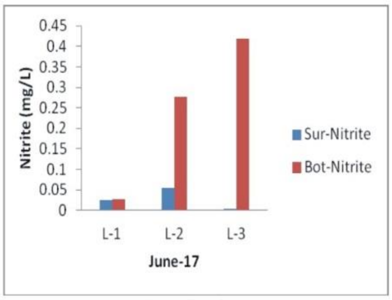

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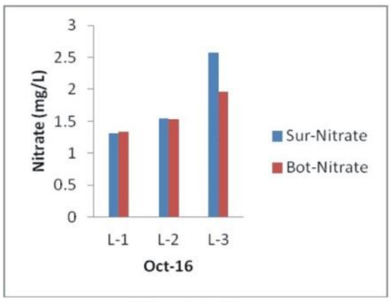

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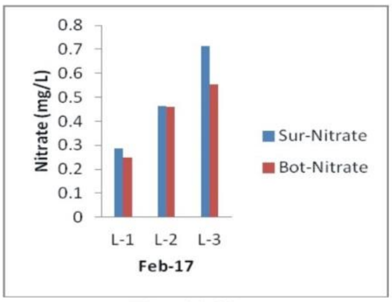

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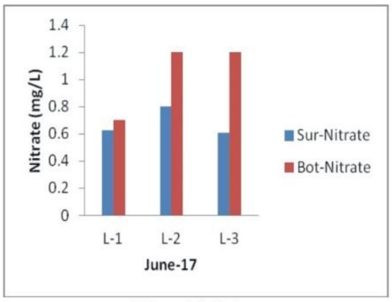

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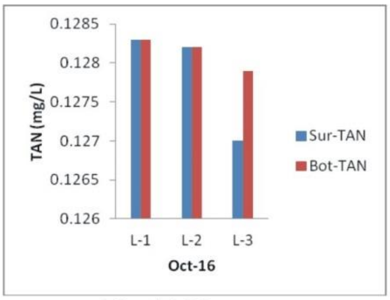

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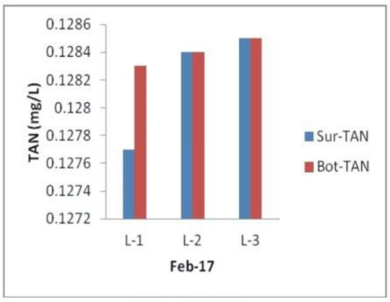

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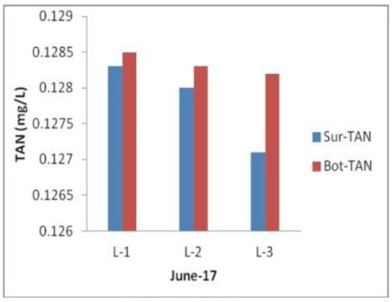

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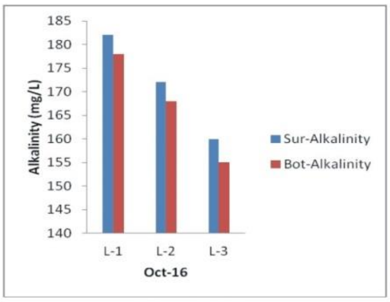

Fig. 11.25

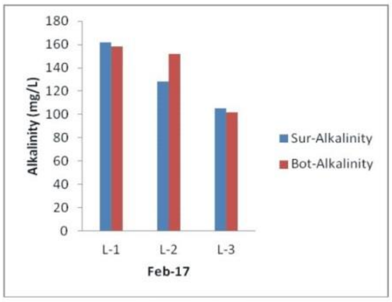

Fig. 11.26

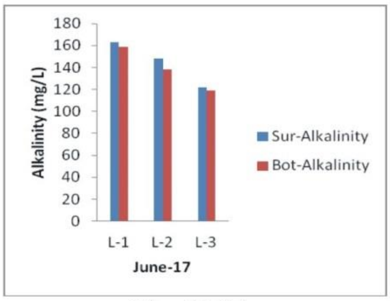

Fig. 11.27

DISCUSSION

4.1. Temperature:

Water Temperature is an important environmental factor for shrimp. The higher the water temperature, higher the metabolic processes in the body of the shrimp. Conversely if temperature is very low, metabolic processes in the body of the shrimp is inhibited. Temperature is one factor controlling the speed of biochemical reactions and regulating the activities of cultured animals. The temperature below and above the optimum range (28 to 32^{o}C) is known to weaken the immune status of the shrimp making it more susceptible to diseases caused by Vibrio Species. Temperature can also affect processes important to dissolved oxygen level in water such as the solubility of oxygen, and the rate of oxidation of organic matter. In addition the solubility of fertilizers can be affected by temperature (Ronald et al., 1999).

Two way ANOVA results clearly showed that there were no significant differences in the water temperature among the three locations in three seasons. But the fluctuations in temperature were attributed to the atmospheric conditions. Relatively lower temperatures were reported in Post-monsoon (S2) coinciding with winter season, relatively higher temperatures were reported in Pre-monsoon (S3) was coinciding with the summer and moderate temperatures were reported coinciding with monsoon. These observations are coinciding with previous studies in this estuary (Sai-Sastry et al., 1990) and reasonably good correlation was observed between the temperature of the atmosphere and that of the water column as reported in other estuarine areas (Rams Sarma 1965; & Rangarajan 1958).

4.2. pH:

The pH of water is its hydrogen ion concentration ([H+]). It is expressed as the negative logarithm of the hydrogen ion concentration (- log [H+]). The shrimp should not experience stress in adjusting pH of the body to its environment. pH in pond waters should be maintained in the range of 7.5-8.5. The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas (Boyd, 1979).

Two way ANOVA results clearly showed that there were no significant differences in the water pH among the three locations in three seasons. Relatively high p^H values are obtained for monsoon and pre-monsoon when compared with post monsoon is due to removal of CO_2 during the process of photosynthesis (Rajasegar, 2003).

4.3. Salinity:

Optimal salinity is required for shrimp to establish the metabolic processes properly. If the salinity in the shrimp body fluids is higher than the environment, the water in the environment will enter into the shrimp body so that the cell will swell. On the contrary, if the environmental salinity is higher than the salinity of shrimp body fluids, the water in the shrimp body will come out so that the shrimp become thin. Optimal salinity for growth of shrimp is 15-30 ppt. Researchers indicated that a population of *L. vannamei* juveniles infected by IHHNV (Infectious Hypodermal and Hematopoietic Necrosis Virus) grew at a slower rate when reared in a high salinity (49 ppt) than in lower salinities (5-15 or 25 ppt) .

Two way ANOVA results clearly showed that there were no significant differences in the water salinity among the three locations in three seasons. But it is observed that salinity increases from L-3 to L-1(table.1). i.e towards mouth which shows that the Vasistha Godavari is normal like any other Indian estuaries (Ramanadham et al., 1975; & Cherian et al.,1975). Maximum salinity was reported (table.1) in the premonsoon coinciding with summer. The results of present study coincide with previous studies.

4.4. Dissolved Oxygen:

Dissolved oxygen (DO) is a very basic requirement for aquaculture species. It is usually the first limiting factor to occur in pond culture. Dissolved oxygen is a complex parameter be- cause its concentration is dependent upon many process. DO Concentrations below 4 ppm make shrimp difficulty capturing oxygen, and the shrimp will rise to the surface of the water to get oxygen.

Two way ANOVA results clearly showed that there were no significant differences in dissolved oxygen among the three locations in the three seasons. But the dissolved oxygen showed remarkable seasonal variations. Dissolved Oxygen concentration was registered high during the post monsoon followed by pre monsoon and monsoon (table.1). High values of DO in post monsoon may be due to, oxygen enters water through photosynthesis by aquatic plants, principally phytoplankton (Watt, 2000) and by diffusion at the air-water interface. Waves and wind help put oxygen into the water. Total absence of anoxic conditions and oxygen reaching super saturation levels during the study period indicated the absence of organic pollution.

4.5. Biochemical Oxygen Demand:

The Biological Oxygen Demand (BOD) is a measure of the amount of organic compounds that can be biologically oxidized by naturally occurring microorganisms in water and is often used as a surrogate of the degree of organic pollution of water (Clair et al., 2003). It is important in aquaculture because the degradation of organic matter by microorganisms is a major sink for dissolved oxygen.

Two way ANOVA results clearly showed that there were no significant differences in biological oxygen demand among the three locations in the three seasons. But a relatively high concentration of BOD in L-3 in three seasons indicates that organic pollution is more at L-3.

4.6. Nitrite:

Nitrite is formed primarily as an intermediary in conversion of ammonia to nitrate, a process known as nitrification. Because it gets converted to the nitrate end product quickly, high nitrite concentrations are not common in aquatic systems. Nitrite is not a common source water problem. It becomes a problem during operation of recirculating systems where the water is continually reused (Lawson, 1995).

Two way ANOVA results clearly showed that there were no significant differences in nitrite concentration among the three locations in three seasons.

4.7. Nitrate:

Nitrate is the least toxic of the major inorganic nitrogen compounds. It is formed as the end product of the nitrification process and concentrations are generally higher than both ammonia and nitrite. High levels of nitrate can affect the Osmoregulation and oxygen transport (Lawson, 1995). The optimum concentration of Nitrate for brackish water aquaculture is 0.1-0.2 mg/L.

Two way ANOVA results clearly showed that there were no significant differences in nitrate concentrations among the three locations. But the nitrate showed remarkable seasonal variations. Nitrate concentration was registered high during the monsoon followed by pre monsoon and post monsoon (table.1). Relatively high concentration of nitrate in monsoon at low salinities may be due to anthropogenic inputs, industrial effluents and organic wastes from catchment area of the river may be major causes of high nitrate concentrations (Gouda et al.,1995; & Nair et al., 1983). Relatively low concentrations of nitrate during post monsoon and post monsoon may be due to the marine water incursion having negligible amount of nitrate and its utilization by biological activity.

4.8. Total Ammonia Nitrogen:

Ammonia is present in water in two forms, a toxic un-ionized ammonia (NH_3) form and a non-toxic ionized ammonia (NH_4^{+}) form. The relative amounts of these are dependent on the pH of water and to a lesser extent on water temperature. The percentage of the toxic form increases as pH and temperature increases during the day and can reach critical levels. The optimum concentration of TAN for brackish water aquaculture is 0.1-1.0 mg/L (Clifford, 1994).

Two way ANOVA results clearly showed that there were no significant differences in TAN concentrations among three locations in three seasons.

4.9. Alkalinity:

Alkalinity is a measure of the acid neutralizing capacity of water. For the purpose of aquaculture, it is a convenient measure that the degree to which water can neutralize acidic, wastes and other acidic compounds and subsequently prevent extreme pH shifts, which can disturb the biological processes of the aquaculture species. Most of alkalinity composed of carbon ions (CO_3^{2-} and HCO_3^{-}) their proportions depends on pH. At pH about 4, most of the alkalinity is in the form of CO_2, as the pH increased Bicarbonate becomes more common until 8.3, as pH continues to raise Carbonate becomes more common (Meade, 1989).

Two way ANOVA results clearly showed that there were no significant differences in alkalinity concentrations among the three locations in three seasons. From the values reported in the study area (table.1) it is conclude that alkalinity is in the form of bicarbonates.

Table 1: Mean±SD values of Water quality parameters in three different locations (L1, L2 & L3) in Vasistha Godavari estuary during the three seasons (S1, S2, & S3)

Season	Location	Temperature (°C)	pH	Salinity (ppt)	DO(ppm)	BOD (ppm)	Nitrite (ppm)	Nitrate (ppm)	Total Ammonia Nitrogen (ppm)	Alkalinity (ppm)
S1	L1	29±0.0	8.03±0.02	17.58±7.64	5.77±0.30	0.52±0.25	0.02±0.004	1.32±0.02	0.12±0.0	180±2.82
	L2	29±0	8.07±0	13.54±5.81	5.66±0.77	0.98±0.63	0.03±0.0007	1.53±0.01	0.128±0.0	170±2.82
	L3	29±0.0	8.36±0.14	0.60±4.41	6.64±1.65	1.66±0.62	0.02±0.007	2.26±0.43	0.12±0.0006	157.5±3.5
S2	L1	28±0.70	8.25±0.26	24.73±2.95	7.96±0.39	1.64±0.39	0.037±0.002	0.26±0.027	0.128±0.004	160±2.82
	L2	26.25±1.0	7.97±0.03	17.85±3.32	7.40±1.14	0.36±0.96	0.04±0.011	0.46±0.003	0.128±0	140±16.9
	L3	28.5±0.70	7.7±0.007	17.85±4.55	8.08±0.67	1.28±0.56	0.049±0.001	0.63±0.11	0.128±0	103.5±2.1
S3	L1	32±0.70	7.81±0.07	32.01±3.44	7.28±0.33	1.28±0.33	0.02±0.002	0.66±0.05	0.128±0.0001	161±2.82
	L2	31±0.70	8.07±0.12	22.27±8.20	6.20±1.30	1.92±0.67	0.16±0.15	1.0±0.28	0.12±0.0002	143±7.07
	L3	33.5±0.70	8.21±0.33	15.63±7.54	6.48±2.82	2.0±0.33	0.21±0.29	0.90±0.41	0.12±0.0007	120.5±2.1

Table 2: Two factor ANOVA

Source of Variation	SS	Df	MS	F	P-value	F crit
Rows	526.3008924	7	75.18584177	1.017672387	0.4307851@	3.02849
Columns	137988.6618	7	19712.66597	266.8193288	9.68131E-3*	3.02849
Error	3620.129909	49	73.88020222			
Total	142135.0926	63				

* Significant ($p < 0.01$), @ NS (Not Significant)

CONCLUSION

The present study summarizes the seasonal fluctuations of various physico chemical parameters for brackish water aquaculture with respect to aquaculture farm periods in the Vasistha Godavari Estuary as exploratory statistical data output, has provided information about the water quality status of Vasistha Godavari Estuary and its suitability for aquaculture uses. The results shows that, there is significant relationship between the Temperature, pH, Salinity, D.O. B.O.D. Alkalinity, Nitrite, Nitrate and TAN across the time periods. The results also show that there is no significant relationship between the Temperature, pH, Salinity, D.O. B.O.D. Alkalinity, Nitrite, Nitrate and TAN across three locations. Based on the present study it is observed that the water is suitable for the brackishwater aquaculture as all the quality parameters are within the prescribed norms and the water can be used for brackish water aquaculture. Hence the study area have high potential for brackish water shrimp culture development based on values obtained which were in conformity with recommended values for shrimp culture.

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