IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 17, Issue 4 Ser. I (April 2023), PP 65-71
www.iosrjournals.org

Nutrient Behaviour and Eutrophication Assessment in the Visakhapatnam Harbor Waters, Andhra Pradesh India

Dr. V.V.Ravindra
[1]*INCHARGE, DEPARTMENT OF CHEMISTRY, SVRK GDC NIDADAVOLE E.G.DIST – A.P., India.*
Dr. P Srinivasa Rao
[2] *Associate Professor, DEPARTMENT OF CHEMISTRY ANDHRA UNIVERSITY, VISAKHAPATNAM– A.P., India.*

Abstract:
More home sewage and industrial effluents are entering harbour waterways as a result of Visakhapatnam's rapid industrialization and urbanisation. Five stations were used for a year-long study on the effects of nutrient pollution and the evaluation of nutrient pollution on the quality of waters in the Visakhapatnam harbor. The eutrophication in these waters was accelerated by the nutrient enrichment. The inner harbor waters become more stagnant as a result of the outer harbor's construction delaying the tidal flushings. The distribution of these nutrients over the study period implies a flow of surface waters that were pollutant-rich towards the sea. Nutrient index has been used to quantitatively determine the degree of nutrient eutrophication in the harbor waters (I). All nutrients' index values in the port waters (I>5) proved the amount of eutrophication in harbor waters. Moreover, the values of the nutrient index declined from the inner harbour to the outside harbour waters, indicating mesotrophic conditions there. This is a result of the dispersion of home sewage and industrial effluents containing organic matter into the outer harbour and the coastal waters of the Bay of Bengal after being discharged into the inner harbor.
Keywords*: Nutrients behavior, eutrophication, Visakhapatnam harbor waters.*

Date of Submission: 03-04-2023 Date of Acceptance: 14-04-2023

I. INTRODUCTION

The water quality of Visakhapatnam harbor is deteriorated by the discharge of combined domestic and industrial effluents. There have been reports of pollution studies in the harbor waters of Visakhapatnam (1-7). To examine the nutrient pollution in the harbor waters, it appears that no systematic investigation has been done. Despite being a recognized issue in freshwater environments, eutrophication has not received much attention in marine environments. It may be started by a number of different natural factors that lead to the organic enrichment of water bodies, but typically speaking, anthropogenic impacts are what make it into a widespread occurrence. Environmental scientists and resource managers are very concerned about the potential for eutrophication of harbor and coastal waters caused by the disposal of biological wastes containing nutrients (7). Estimate for eutrophication detection and measurement. They do, however, necessitate laborious data gathering and processing. Nutrient-salinity relationships for assessing the dilution and transportation of sewage effluents (2, 3), as well as N:P atomic ratios (8) for characterizing eutrophication conditions in the marine environment, are other easier ways to evaluate the water quality. Karydis et al. (8) developed a simpler method based on the calculation of nutrient index designed to be specific for each nutrient to evaluate eutrophication levels in the marine environment influenced by domestic sewage because none of the methods mentioned above could quantitatively explain the eutrophication. The current message discusses the quantitative assessment of nutrient eutrophication levels in harbor waters based on this method, as well as individual nutrient distribution, behavior, and fluctuations in hydrographic conditions.

II. MATERIALS AND METHODS

The harbr in Visakhapatnam is a natural harbour and one of India's busiest ports. It is situated at a latitude of 17° 42' 00" North and a longitude of 83° 23' 00" East on India's central east coast. The port is split into two areas: the outer harbour and the inner harbour. A narrow entrance canal connects the inner harbour, which has 6 berths and a 200-hectare water spread, to the outer harbour. The northern, northwestern, and western arms of the inner harbour, which all unite at the turning basin, extend in three different directions. The "southern lighter channel," a key component of the city's drainage system, also leads to a turning basin. Freshwater flowing from the reservoir that is fueled by the monsoon. During monsoon season, the inner harbor's waters become brackish because the reservoir "Mehadrigedda" pours into the northern arm at its end. The stream also serves as a significant polluting source because it carries several effluents from numerous large, medium, and small companies, including Visakha Dairy, Hindustan Zinc Ltd., Coromandal Fertilizers Ltd., and Hindustan Petroleum Corporation Ltd. Hence, there is a pollution gradient in the area between the inner harbour and the outer harbour (7, 16, 17). Domestic sewage from the city (3 x 103 m3 per day) and industrial effluents (6 x 105 m3 per day) from the nearby industry are both discharged into the port.

In the harbour waters, five stations in the year 2021–2022 were used to collect monthly surface and bottom water samples throughout the course of a year. The results are displayed in Fig.1. Clean plastic buckets are used to collect surface waters, while Niskin bottom water samplers are used to collect bottom waters. After collection, the waters were immediately filtered via Glass Fiber GF/F filter papers. Salinity, nitrite, nitrate, ammonia, phosphate, and reactive silicate were all determined using filtered waters, and their respective concentrations were 0.02, 0.02, 0.01 and 0.02 M. The Winkler's modified method is used to measure dissolved oxygen (19). Using glass and calomel electrodes, an Elico pH metre is used to test pH.

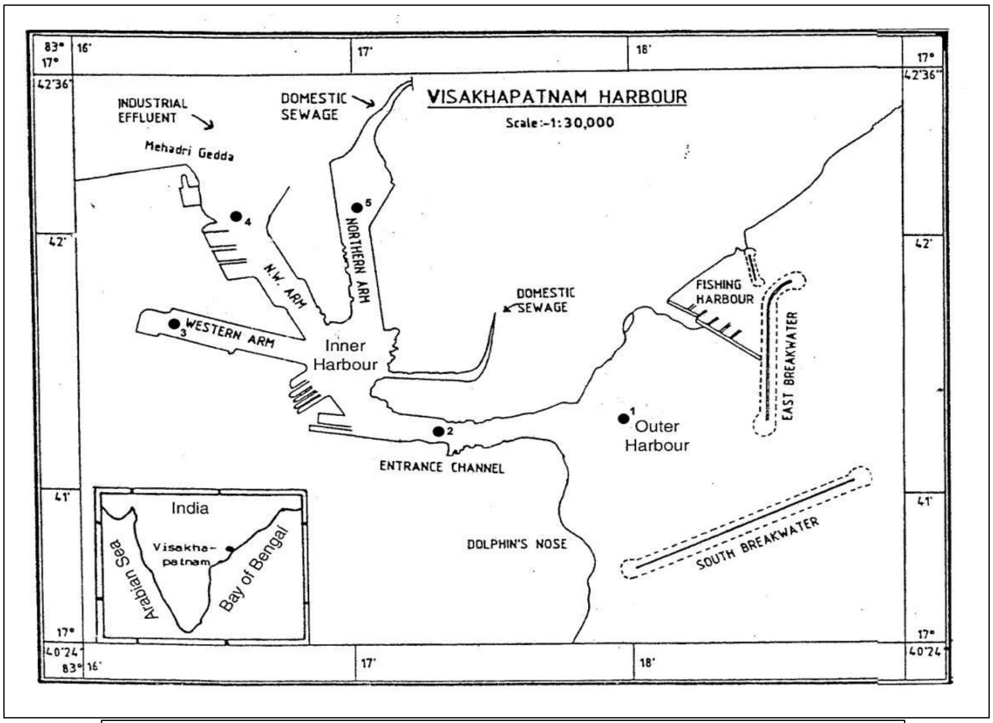

FIG.1. STATION LOCATIONS AT VISAKHAPATNAM

Statistical data on hydrography and nutrient parameters in the harbor waters during the study period aregiven in Table 1. Annual average concentrations of hydrography and nutrients at individual stations are shown in Fig. 2 and 3 are discussed below.

TABLE 1
STATISTICAL DATA ON THE HYDROGRAPHY AND NUTRIENT PARAMETERS IN THE VISAKHAPATNAM HARBOR WATERS DURING 2021 – 2022

Parameter	Surface				Bottom			
	Min.	Max.	Mean	S.D (±)	Min.	Max.	Mean	S.D (±)
Temp. (^{O}C)	28.00	32.00	30.39	1.06	27.00	30.80	29.14	0.91
pH	6.03	8.03	7.30	0.51	7.04	8.09	7.72	0.24
Salinity (psu)	19.24	34.39	20.18	3.26	26.94	35.64	32.11	2.28
D.O. (mg/L)	4.79	15.70	8.68	2.46	3.51	7.89	5.87	0.77
Chl-a (mg/m^3)	10.00	245.50	57.43	44.35	3.50	42.32	13.17	8.23
Nitrite (µM)	1.39	64.40	18.86	15.24	0.37	51.50	9.67	9.74
Nitrite (µM)	4.83	106.00	32.07	25.47	3.28	47.00	15.62	12.48
Ammonia (µM)	12.00	100.90	44.20	23.10	2.98	57.42	23.33	11.98
Phosphate (µM)	22.80	279.00	72.62	49.07	8.32	119.23	39.83	23.83
Silicate (µM)	10.80	100.23	42.93	23.54	2.56	60.63	19.43	11.49

TEMPERATURE:

In the surface waters, temperatures vary from 28.0 to 32.0ºC with an average of 30.39oC, while in the bottom waters, temperatures ranged from 27.0 to 30.8oC with an average of 29.14oC. Maximum and minimum temperatures were both recorded in May 2021 and January 2022, respectively. The surface and bottom temperatures climbed starting in March 2021 and peaked at all sites in May 2021. The upward trend persisted through July 2021. Following the apex, the temperature displayed a declining trend at all stations up to January 2022. In large part, the temperature dispersion was a reflection of the local climate. Pre-monsoon is the time of year with the highest temperature, followed by post-monsoon and monsoon.

pH :

Surface water pH levels range from 6.03 to 8.03, with an average of 8.03, while bottom water pH values range from 7.04 to 8.09, with an average of 7.72. During March to July (pre-monsoon), when marine conditions predominated more and more in the harbour waters, the pH levels climbed. During August to November (during the monsoon), when the harbour experienced a significant input of freshwater, it displayed a decreasing tendency. Due to the infiltration of very saline water into the bottom, the pH values of the surface were always lower than those of the bottom.

Due to the discharge of (acidic) effluents from a fertiliser complex (Coramandal Fertilizer Limited) and a zinc smelter (Hindustan Zinc Limited) in the station's upper reaches, St. 4 had the lowest pH values of any of the stations. Due to the city's domestic sewage being discharged, the values at St. 5 were also low. These waters (6, 8) and the river Par and its abatement, where industrial effluents predominated, have seen similar pH changes in the past (22).

Salinity:

The harbor's surface waters had salinities that ranged from 19.24 to 34.39 (psu), with an average of 30.18 (psu), whereas the bottom waters had salinities that ranged from 26.94 to 35.64 (psu), with an average of 32.11 (psu) (psu). Highest salinity levels are seen in the bottom waters of St. 1 in May, while minimal salinity levels are seen in the surface waters of St. 4 during the monsoon season. The following pattern of salinity distribution in the harbour waters may be seen from the monthly distribution of salinities. From March to June 2021, a period of rather high salinity was recorded, and from December 2012 to February 2022, a period of intermediate salinity was recorded. Similar trend of salinities in the harbor and coastal waters are reported earlier (6, 20, 21).

Dissolved oxygen:

The surface waters dissolved oxygen values ranged from 3.79 to 15.70 mg/L with an average of 8.68 mg/L, whereas the bottom waters' values ranged from 3.51 to 7.89 mg/L. Due to the creation of multiple planktonic blooms that have already been observed in these waters, the surface waters are extremely saturated with dissolved oxygen (4). Due to the current weather circumstances, which are conducive for the establishment of planktonic blooms, higher quantities of dissolved oxygen were seen during the post-monsoon and pre-monsoon seasons (23). Due to the unfavourable conditions for bloom development and the monsoonal runoff, which transports organic wastes into harbour waters and uses oxygen for the degradation, low amounts of D.O. were detected during the monsoon season. During the study period low oxygen concentrations were observed in the bottom waters at stations 3 to 5 are attributed to the oxidation of organic matter.

NUTRIENTS

Nitrogen Species:

The harbour waters have abnormally high concentrations of nitrite, nitrate, and ammonia. The highest concentrations of these nutrients are found at stations 2 through 5. Nitrite concentrations in surface waters ranged from 1.39 to 64.40 M, with an average of 18.86 M, while concentrations in bottom waters ranged from 0.37 to 51.50 M, with an average of 9.67 M. Nitrate concentrations in surface waters ranged from 4.83 to 106 M, with an average of 32.07 M, while concentrations in bottom waters ranged from 2.28 to 47 M, with an average of 15.62 M. In the surface waters, ammonia concentrations ranged from 12.00 to 100.90 M, with an average of 44.20 M, whereas in the bottom waters, Its concentrations ranged between 2.98 and 57.42 M, with an average of 23.33 M. Ammonia is the most abundant of the three nitrogen species in harbour waters.

The maximum concentrations of these nutrients are observed at Sts. 3 - 5 when compared to St. 1. Nutrient enrichment through pollution was reported from other marine environments (24, 25). The enrichmentof nutrients enhances the eutrophication and stimulates the algal growth. The seasonal variation in all the nitrogen constitutes shows similar trend at all stations. Seasonally, higher concentrations of these nutrients were observed during monsoon season due to the discharge of more industrial effluents and domestic sewage into the harbor waters, followed by post and pre-monsoon seasons. Higher concentrations of nitrogen species in surface waters may be the reasons for plankton peaks as reported earlier (26, 27).

Phosphate :

Phosphate concentrations ranged from 22.80 to 279.00 µM with an average of 72.62 µM in the surface waters, where as in the bottom waters its concentration varied from 8.32 to 119.23 µM with an average of 39.66 µM. Higher concentrations of phosphate observed in surface waters of all stations in the harbor. St. 4 recorded highest concentrations of phosphate (279 µM) in October in the surface waters. This could be attributed to the influence of influx of industrial effluents and land drainage in this station. Seasonally, higher concentrations of phosphate were observed during monsoon than those of pre-monsoon and post-monsoon seasons. The maximum concentrations of phosphate in the harbor waters during monsoon season due to the release of industrial effluents from the Coromandel Fertilizer Limited and spillage during loading / unloading of fertilizer. Similar seasonal variations were also observed in the estuarine complex of Cochin (28), off Malpe, South Kanara in the near shore region of Thal, Maharashtra (29). A pronounced horizontal gradient (downward) existed in the concentrations of phosphate from Sts. 3 - 5 to St. 1.

Silicate :

Silicate concentrations ranged from 10.80 to 109.23 µM with an average of 42.93 µM in the surface waters, where as in the bottom waters its concentration varied from 2.56 to 60.63 µM with an average of 19.43 µM. Higher concentrations of silicates were observed during August to October (Monsoon) and lower concentrations were observed during March to May (Pre-monsoon season). High concentrations of silicate in monsoon season is a common occurrence in the coastal and harbor waters (30, 31). It is well known fact that land-born runoff is the chief source for silicate while its removal utilization by phytoplankton and adsorption into the suspended sediments are in the main processes operative in the marine environment (32, 33). With high concentration of silicate in the harbor waters an intense growth of diatoms like *Skeletonema costaum* and *Cyclotella meneghenina* occurs. Major peaks in diatoms production were reported earlier during October to November when the concentrations of silicate also were observed to be maximum (6, 34). Relatively low concentrations of silicate were observed during pre and post-monsoon season may be either to its supply being less (from runoff) or to its biological utilization into both processes operating simultaneously. In general, surface concentrations of silicate were higher than those of bottom waters. Relatively, high values of silicate (100.23 µM) were observed in the surface waters of St. 4, which drastically fell in the direction of St. 1.

Chlorophyll-a : Phosphate concentrations ranged from 10.00 to 245.50 $mg.m^3$ with an average of 57.43 $mg.m^3$ in the surface waters, where as in the bottom waters its concentration varied from 3.50 to 42.32 $mg.m^3$ with an average of 13.17 $mg.m^3$. Highest concentrations of Chlorophyll-a were observed in January & February and lowest values were observed during July to September. Higher values of chlorophyll-a were observed during pre and post-monsoon season which may be attributed to the favorable conditions of nutrient supply, light intensity and temperature in the ambient waters that led to maxima in primary production. Lower concentrations of chl-a were observed during monsoon season, may be attributed to the unfavorable conditions like high turbidity, low light, low salinity and low pH. Chl-a values were relatively higher at St. 4 (245.5 $mg.m^3$) in the surface waters, when compared to other stations due to the continous supply of ammonia and phosphate to this station from the industrial effluents of Coramandel Fertilizer industry.

Inter-correlations of hydrography and nutrients parameters

The correlation coefficients have been computed among hydrography and nutrient parameters to understand inter-relationships in the harbor waters is given in Table 3.

Table 3
Correlation between hydrography and nutrient parameters in theVisakhapatnam harbor waters during 2021-2022

	Temp.	pH	Salinity	D.O.	NO_2	NO_3	NH_4	PO_4	SiO_4
pH	-0.23								
Salinity	0.04	0.76					N =120		
D.O.	0.31	-0.16	-0.09				P<0.0001		
NO_2	0.33	-0.82	-0.69	-0.03					
NO_3	0.25	-0.89	-0.80	-0.01	0.91				
NH_4	0.33	-0.84	-0.73	0.15	0.88	0.88			
PO_4	0.33	-0.84	-0.73	0.15	0.88	0.88	0.98		
SiO_4	0.40	-0.85	-0.68	0.29	0.85	0.85	0.92	0.92	
Chl-a	0.39	-0.25	-0.17	0.82	0.18	0.15	0.36	0.36	0.50

Significant inverse correlations (p = < 0.001) were observed between salinity and nutrients in the harbor waters indicating that distribution of these parameters is believed to be primary govern by land runoff along with industrial effluents and domestic sewage. Similar observations have been reported by several workers in different coastal environments of India. Significant positive correlations were observed between pH and salinity indicates that pH increases with increase of salinity. Significant negative correlations were observed between salinity, pH and nutrients may be attributed that the nutrient concentrations are decreased with increasing pH and salinity. Significant positive correlations were observed between chlorophyll-a and dissolved oxygen, indicating that most of the dissolved oxygen produced in the harbor waters through phytoplanktonic photosynthesis. Significant positive correlations were observed within the nutrients attributing their common sources of occurrence in the harbor waters. Chlorophyll-a moderately correlated (positive) with ammonia, phosphate and silicate attributing that these waters are eutrophic in nature.

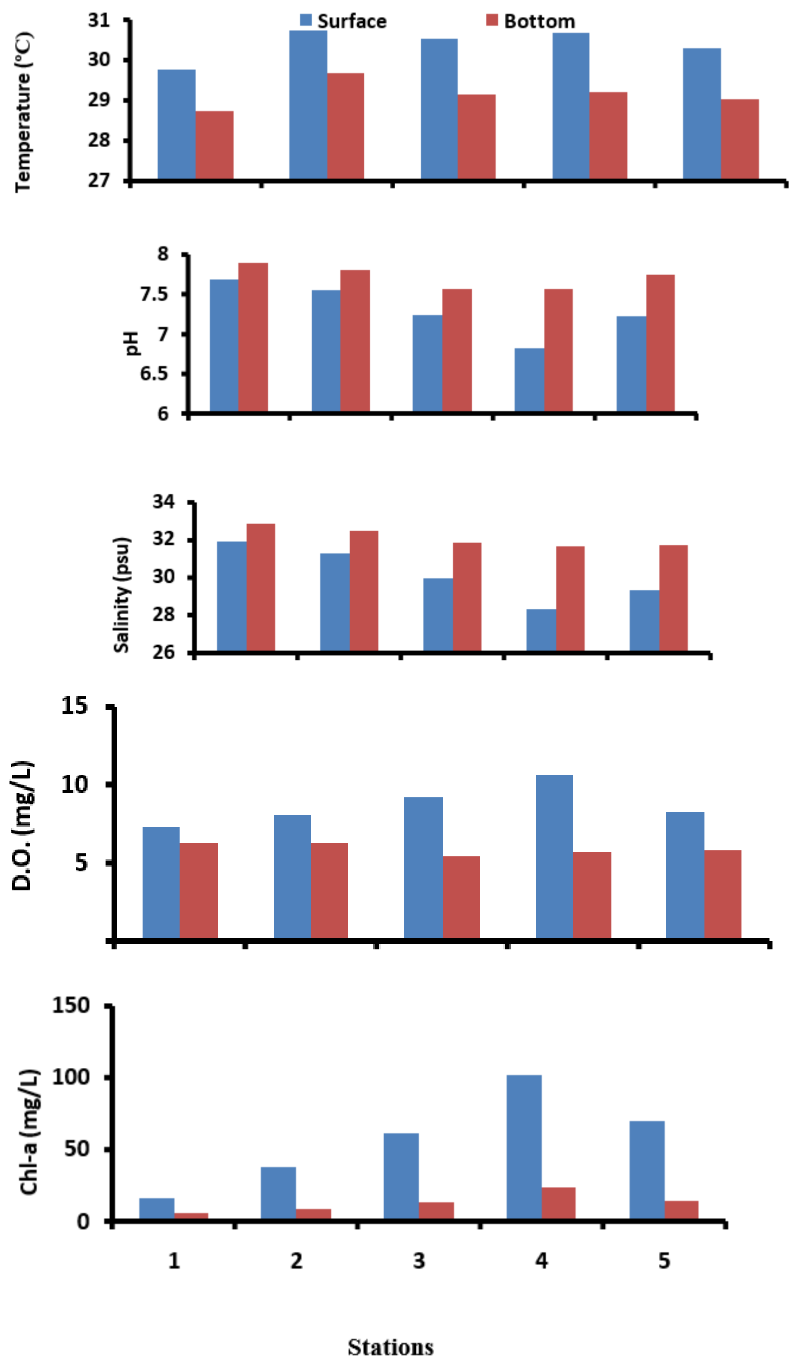

Fig. 2. Station-wise (annual mean) variations of hydrographic parametersin the Visakhapatnam harbor waters during 2021-2022

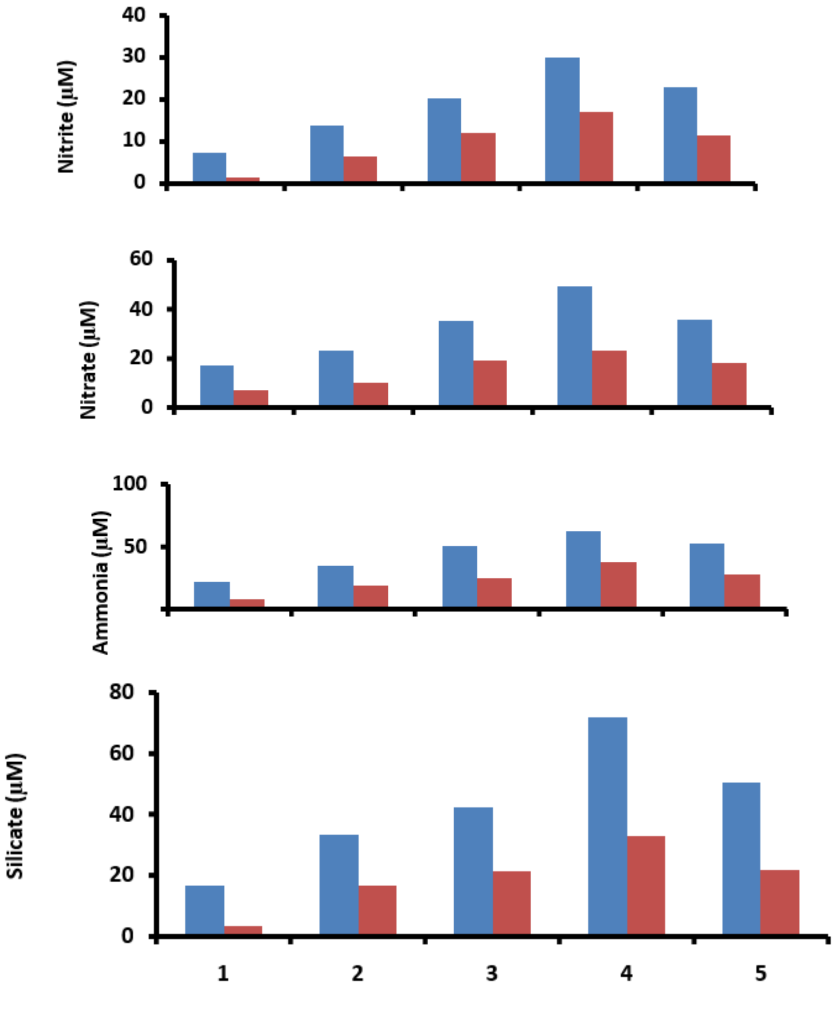

Fig. 3. Station-wise (annual mean) distribution of nutrients parametersin the Visakhapatnam harbor waters during 2021-2022

Acknowledgement : The author thank the authorities of the Visakhapatnam Port Trust for boat facilities.

[1]. P. N. Ganapathi and A. V. Raman, Ind. J. Mar. Sci., **1979**, **8** : 184 - 187
[2]. P. N. Ganapathi and A. V. Raman, Curr. Sci, **1973, 42 :** 490 - 492.
[3]. P. N. Ganapathi and A. V. Raman, Ind. J. Mar. Sci., **1976a**, **5** : 134 - 135.
[4]. P. N. Ganapathi and A. V. Raman, Ind. J. Mar. Sci., **1979b**, **5** : 251.
[5]. P. N. Ganapathi and A. V. Raman, Ind. J. Mar. Sci., **1979**, **8** : 184 - 187.
[6]. Subba Rao, B. V. S. S. SR, R.Venkateswara Rao, Ind. J. Mar. Sci., **1980**, **9** : 222 – 223.
[7]. V. V. Sarma, G. R. K. Raju, T. Bose Babu, Mahasagar-Bulltn. Natn. Institut. Oceanogr., **1982**, **15** : 15 - 22.
[8]. A. V. Raman, P. N. Ganapati, Mar. Pollut. Bulltn, **1983**, **14** : 46 - 52.
[9]. A. V. Raman, P. N. Ganapati, Ind. J. Mar. Sci., **1986**, **15** : 132 - 133.
[10]. C.B. Officer, J.H. Ryther, Science Wash, **1977**, **197 :**1056.
[11]. G.G. Hooprt in Eotropicatronic causes consequences, correctives (National Academy of Sciences, Washington D.C), **1969** :225. S.E. Cook, Environ. Pollu., **1976**, **11 :**269.
[12]. C. Garside, T.C. Malone, O.A. Roels, B.A. Sharistein, Estuar. Coast Mar. Sci., **1976**, **4** : 281.
[13]. I.W. Duedall, H.B. O'Connors, J.H.Parkar, R.E.Wilson, A.S.Robbins, Estuar Coast Mar. Sci., **1977**, **5 :** 81
[14]. N.Frilgos, Mar. Poll. Bull. **1981**, **12 :** 96.
[15]. J.H. Ryther, W.M. Dustan, Sci. Wash, **1971 : 171**, 1008.
[16]. M. Karydis, L.Ignatlades, N. Moschopoudou, Estuar. Coast. Shelf Sci., 1983, 16 : 339-334.
[17]. S.C. Tripathy, B.A.V.L. Kusuma Kumari, V.V.Sarma, T.V. Ramana Murthy, Asian J. Microbiol, Biotech. Env. Sci., **2005**, **7 :** 831-835.
[18]. S.K.Pati, M.V.Rao, M. Balaji, Ind. J. Mar. Sci, **2013**, **42 :** 487-497.
[19]. K. Grashoff, M.Ehrhardt, K. Kremling (eds.), 1983. Methods of sea water analysis. Verlig Chemie Weinheim.
[20]. D.E. Carritt, J.H. Carpenter, J. Mar. Res., 1966, 24 : 286-318.
[21]. R. Varadarajulu, M.D.T.A.Khadar, . Ind. J. Mar. Sci, **1976**, **5** :191-121.
[22]. E.C. LaFond, Proc. Ind. Acad. Sci., **1957 : 46**, 1-46.

[23]. D. Zingde, R.V Sarma, B.N. Desai, Ind. J. Mar. Sci, **1979a, 8** : 266-270.
[24]. V.E. Premila, M.U.Rao, Ind. J. Mar. Sci, **1977, 6 ;** 79-81.
[25]. X.N. Verlenkar, Classy D'Silva, Ind. J. Mar. Sci, **1977, 6** : 111-113.
[26]. R.V.Unnithan, M. Vijayan, E.V. Radha Krishna, K.N.Ramani, Ind. J. Mar. Sci, **1977, 6** : 81-83.
[27]. L. Wikinson, Internal. J. Air and Water Pollut. **1963, 7** : 737-752.
[28]. K. Subbaramaiah, R.G. Parekh, Sci. Cult., **1966, 32** : 370.
[29]. R. Pai, M.P.M. Reddy, Ind. J. Mar. Sci, **1981, 10 :** 322-326**.**
[30]. P.K. Varsheny, R. Nair, S.A.H. Abidi, Ind. J. Mar. Sci, **1983, 12** : 27-30.
[31]. A. Purushothaman, V.K. Venugopalan, Ind. J. Mar. Sci, **1972, 1** : 103-105. 83.
[32]. P.S. Joseph, Ind. J. Mar. Sci, **1974, 3** : 28-32.
[33]. G.S. Bein, D.E.Contois, W.H. Thomas, Geochem. Cosmochem. Acta, 1958, 4 : 35-54.
[34]. P.S. Liss, C.P. Spencer, Geochem. Cosmochem. Acta, 1970, 37 : 1493-1498.
[35]. M. Umamaheswara Rao, V. Premchand, Mar. Env. Res., **1988, 25** : 23-43
[36]. A.V. Raman, K.Pani Prakash, Ind. J. Mar. Sci., 1989, 18 : 33.

Dr. V.V.Ravindra, et. al. "Nutrient Behaviour and Eutrophication Assessment in the Visakhapatnam Harbor Waters, Andhra Pradesh India." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 17(4), (2023): pp 65-71.