SEASONAL CHANGES ON EUTROPHICATION LEVELS OF THE COASTAL SEA WATER AROUND THE KAYINDAUNG IN TANINTHARYI COASTAL AREA

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Abstract

The aim of this paper is to study the seasonal changes of eutrophication levels of coastal sea water around the Kayindaung in Tanintharyi Coastal Area. Sea water samples were collected from three different sites around Kayindaung in Tanintharyi Coastal Area. Sampling sites were recorded with GPS detector. Some chemical properties such as DO, orthophosphate (inorganic phosphate), organic phosphate, total phosphate and total nitrogen were determined. In this paper, the measured DO values were in the range of 6.86 ppm to 8.21 ppm. The values of orthophosphate, organic phosphate and total phosphate were found to be in the range of 0.014 ppm to 0.186 ppm, 5.311 ppm to 7.838 ppm and 5.325 ppm to 7.969 ppm in seasonally and annually collected sea water samples, respectively. The total nitrogen value in the studied area was found in the range of 0.560 ppm to 1.586 ppm for seasonally and annually collected samples. For eutrophication assessment, the determination of nutrient levels of all sea water samples in hot season were low nutrient-enrichment (oligotropic) and in rainy and cold season were medium nutrient-enrichment (mesotropic) for both seasonally and annually collected samples.

Keywords: Coastal sea water, Kayindaung in Tanintharyi Coastal Area, DO, total phosphate, total nitrogen, Eutrophication level

Introduction

Eutrophication is the most studied form of coastal marine pollution. Eutrophic waters are characterized by excessive algal growth as a consequence of nutrient enrichments of coastal surface waters. This problem, that is high nutrient concentration and algal biomass is commonly called eutrophication. If the coastal waters are nutrient poor with low productivity are characterized as "oligotrophic" whereas, nutrient rich waters with high algal biomass are characrerized as "eutrophic". The intermediate conditions characterize "mesotrophy". The impacts of eutrophication in the marine environment vary according to the enrichment level: slight increase of phytoplankton biomass is followed by changes in community structure (Karydis, 2009).

Biomass production in coastal waters - the conversion of light and carbon dioxide into living organic matter - is mainly limited by availability of nitrogen and/or phosphorus (light is a limiting factor in turbid zones). Eutrophication leads to increased biomass production that disturbs the natural ecological balance in the coastal zone, with serious detrimental consequences for biodiversity, ecosystem resilience, recreational activities and fisheries (Caitlin, 2020).

Materials and Methods

In this research, sea water samples were collected from Kayindaung in Tanintharyi Coastal Area seasonally and annually during 2011-2014. Figure 1 shows the sampling sites of sea water samples by the GPS detector. All samples were collected at a depth of 2m below the surface of sea water. Some chemical properties such as DO, orthophosphate, organic phosphate, total phosphate and total nitrogen were determined. The dissolved oxygen of sea water samples were measured in the field by using a DO meter-Temperature sensor probe HANNA Instrument. Orthophosphate and

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total phosphate were determined by UV-visible spectrophotometric method. Total nitrogen of sea water samples were determined by Azo Dye method.

Figure 1 Satellite image of the sample collection sites (Site A 97 ° 35.966'E, 15° 56.969'N, Site B 97 ° 35.256'E, 15 ° 56.969'N, Site C 97 ° 35.440'E, 15 ° 56.726'N)

Results and Discussion

Dissolved Oxygen in Sea Water Samples

Monitoring dissolved oxygen will provide indication of water quality in coastal areas and used as a tool in ecosystem integrity. Dissolved oxygen is essential to the respiratory metabolism of most aquatic organisms. In this research work, dissolved oxygen content of the sea water samples were found to be in the range of 6.86 ppm to 8.21 ppm for seasonally and annually. Higher dissolved oxygen concentration (8.21 ppm) observed during rainy season (2013) might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing. Optimum concentration of dissolved oxygen is essential for maintaining aesthetic qualities water as well as for supporting life. The value of dissolved oxygen (6.86 ppm) during hot season (2014) is lower due to higher temperature and high rate of microbial decomposition of organic matter. The measured DO values were within the permissible level of ASEAN standard (> 5ppm) (Table 1 and Figure 2).

Table 1 Seasonal Changes of the Dissolved Oxygen Contents in Sea Water Sample

Sr No.	Year	Season	Sampling Sites	Dissolved Oxygen (DO) ppm
1.	2011	Rainy	A	7.41
			B	7.85
			C	7.62
2.	2012	Hot	A	7.65
			B	7.34
			C	7.22
		Rainy	A	7.83
			B	7.79
			C	7.72
		Cold	A	7.71
			B	7.69
			C	7.65
3.	2013	Hot	A	7.15
			B	7.35
			C	7.24
		Rainy	A	8.11
			B	8.05
			C	8.21
		Cold	A	7.72
			B	7.58
			C	7.64
4.	2014	Hot	A	7.09
			B	6.86
			C	7.22
		Rainy	A	7.99
			B	7.81
			C	7.93
		Cold	A	7.72
			B	7.45
			C	7.54
EPA Standard (2009)				>4
ASEAN Standard (2010)				>5

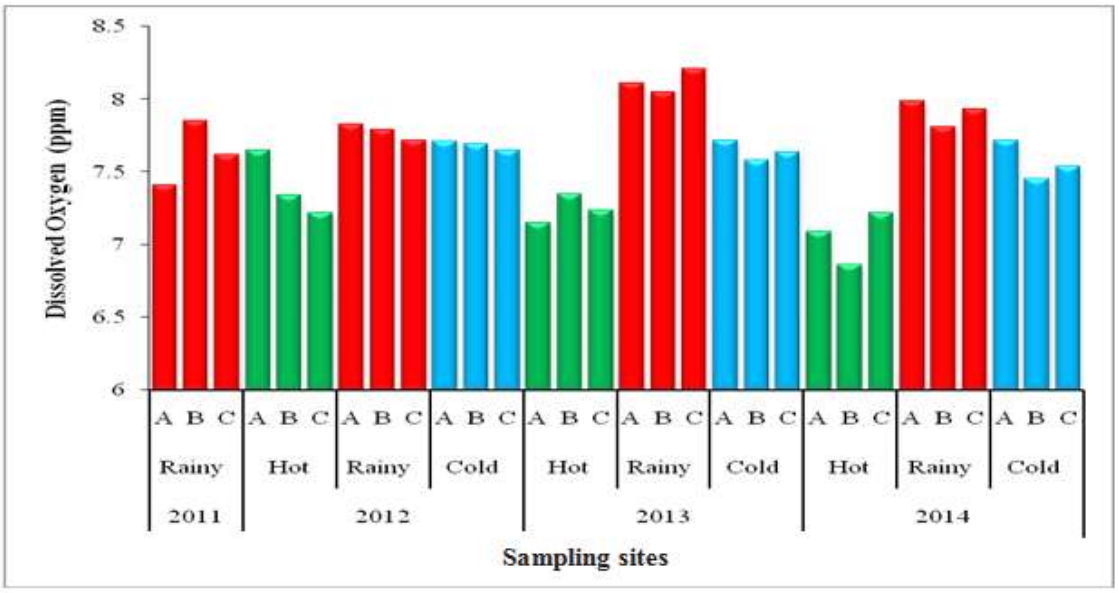

Figure 2 Seasonal changes of the dissolved oxygen values in the sea water samples from the Kayindaung in Tanintharyi Coastal Area

Orthophosphate, Organic Phosphate and Total Phosphate in Sea Water Samples

Phosphorous is an essential element for all life including plant growth and photosynthesis in algae. Phosphorous is considered to be the most significant component among the nutrients responsible for eutrophication of a water body. Phosphate is the most important nutrient for the production of phytoplankton in sea water which is primary food for many of the commercial fishes (Mihajlovie *et al*., 2007).

In water bodies, the phosphorus may be present in various forms. All forms of phosphorus are not readily available to plants. Total phosphate is a measure of all forms of phosphorous (dissolved or suspended) found in water. The soluble reactive phosphorous is a measure of orthophosphate (inorganic phosphate) that is the form directly taken up by plant cells. While monitoring the water bodies, the latter form of phosphorus would be of special significance to determine the stage of eutrophy and oligotrophy (Kyaw Naing, 2011). Agriculture runoff containing phosphate fertilizers as well as the wastewater containing the detergents etc. tend to increase phosphate pollution in water.

In the present work, the orthophosphate concentration of sea water samples were found to be in the range of 0.061 ppm to 0.184 ppm in rainy season (2011), 0.014 ppm to 0.027 ppm in hot season, 0.109 ppm to 0.142 ppm in rainy season, 0.043 ppm to 0.052 ppm in cold season (2012), 0.029 ppm to 0.035 ppm in hot season, 0.131 ppm to 0.186 ppm in rainy season, 0.063 ppm to 0.078 ppm in cold season (2013), 0.027 ppm to 0.034 ppm in hot season, 0.132 ppm to 0.143 ppm in rainy season and 0.039 ppm to 0.058 ppm in cold season (2014), respectively (Table 2 and Figure 3).

The high amount of orthophosphate (0.186 ppm) observed during rainy season (2013) could be due to turbulence and mixing in water column, while the low amount (0.014 ppm) observed during hot season (2012) could be due to the limited flow of fresh water, high salinity and utilization of phosphate by phytoplankton.

The highest and lowest values of organic phosphate were 7.838 ppm and 5.311 ppm. The lowest value (5.311 ppm) was found in hot season, 2012 and the highest value (7.838 ppm) was found in rainy season, 2013 (Table 2 and Figure 4).

Total Phosphate concentration of sea water samples were found to be in range of 5.325 ppm to 7.969 ppm (Table 2 and Figure 5). The highest value of total phosphate was found in rainy season 7.969 ppm (2013). This may be due to the nutrient inputs to aquatic ecosystem, especially agricultural wastes.

Table 2 Seasonal Changes of the Orthophosphate, Organic Phosphate and Total Phosphate in Sea Water Samples

Sr No.	Year	Season	Sampling sites	Ortho phosphate (ppm) Mean ± SD	Organic phosphate (ppm) Mean ± SD	Total phosphate (ppm) Mean ± SD
1.	2011	Rainy	A	0.061 ± 0.003	6.360 ± 0.058	6.421 ± 0.058
			B	0.123 ± 0.005	7.835 ± 0.047	7.958 ± 0.047
			C	0.184 ± 0.005	7.664 ± 0.063	7.848 ± 0.063
2.	2012	Hot	A	0.014 ± 0.002	5.311 ± 0.051	5.325 ± 0.051
			B	0.018 ± 0.003	6.547 ± 0.026	6.565 ± 0.026
			C	0.027 ± 0.003	6.440 ± 0.063	6.467 ± 0.063
		Rainy	A	0.109 ± 0.005	6.680 ± 0.026	6.789 ± 0.026
			B	0.128 ± 0.003	6.627 ± 0.026	6.755 ± 0.026
			C	0.142 ± 0.002	6.645 ± 0.090	6.787 ± 0.090
		Cold	A	0.052 ± 0.003	6.613 ± 0.026	6.665 ± 0.026
			B	0.043 ± 0.003	6.611 ± 0.053	6.654 ± 0.053
			C	0.046 ± 0.005	6.591 ± 0.090	6.637 ± 0.090
3.	2013	Hot	A	0.029 ± 0.002	5.516 ± 0.029	5.545 ± 0.029
			B	0.032 ± 0.003	5.406 ± 0.045	5.438 ± 0.045
			C	0.035 ± 0.003	5.454 ± 0.029	5.489 ± 0.029
		Rainy	A	0.131 ± 0.004	7.838 ± 0.062	7.969 ± 0.062
			B	0.179 ± 0.005	7.655 ± 0.058	7.834 ± 0.058
			C	0.186 ± 0.005	7.670 ± 0.048	7.856 ± 0.048
		Cold	A	0.075 ± 0.004	6.697 ± 0.047	6.772 ± 0.047
			B	0.063 ± 0.003	6.785 ± 0.047	6.848 ± 0.047
			C	0.078 ± 0.003	6.747 ± 0.053	6.825 ± 0.053
4.	2014	Hot	A	0.033 ± 0.003	5.546 ± 0.064	5.579 ± 0.064
			B	0.034 ± 0.003	5.418 ± 0.058	5.452 ± 0.058
			C	0.027 ± 0.002	5.485 ± 0.027	5.512 ± 0.027
		Rainy	A	0.132 ± 0.005	6.449 ± 0.047	6.581 ± 0.047
			B	0.139 ± 0.004	6.293 ± 0.072	6.432 ± 0.072
			C	0.143 ± 0.005	6.369 ± 0.047	6.512 ± 0.047
		Cold	A	0.058 ± 0.004	6.068 ± 0.029	6.126 ± 0.029
			B	0.045 ± 0.004	6.194 ± 0.043	6.239 ± 0.043
			C	0.039 ± 0.003	6.209 ± 0.055	6.248 ± 0.055
EPA Standard (2009)				-	-	-
ASEAN Standard (2010)				0.015	NC	<0.05

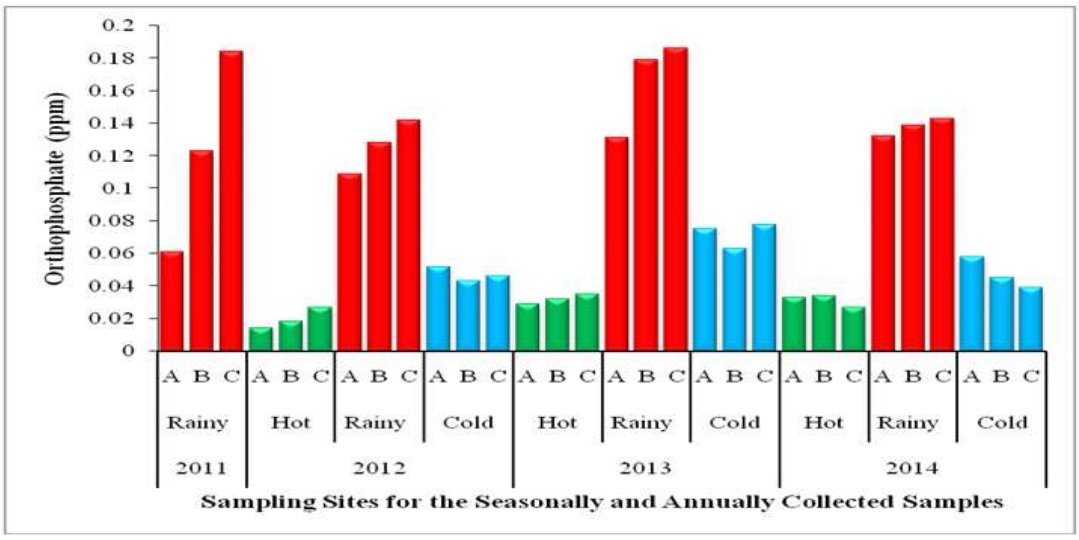

Figure 3 Seasonal changes of the orthophosphate values in the sea water samples from the Kayindaung in Tanintharyi Coastal Area

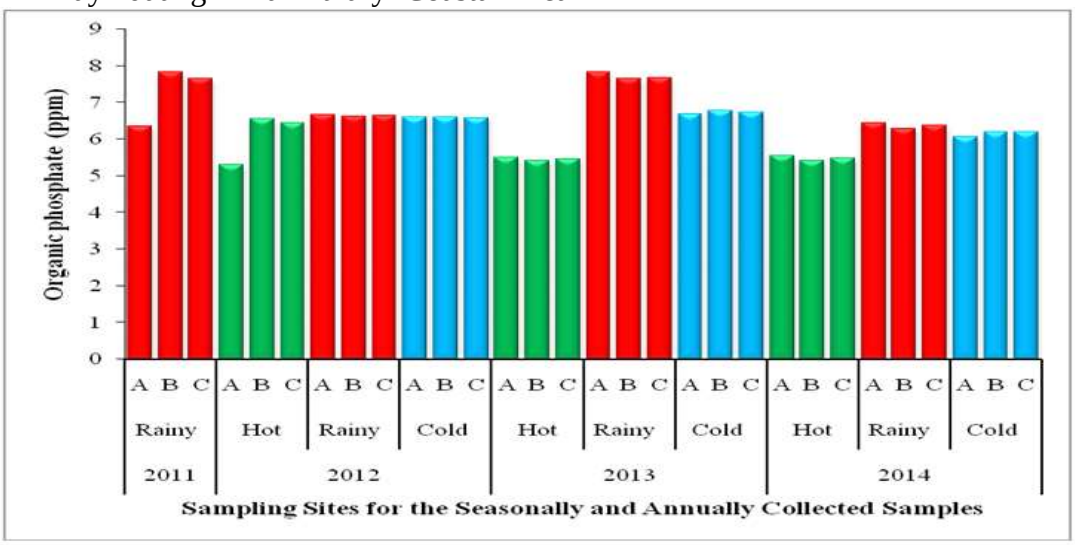

Figure 4 Seasonal changes of the organic phosphate values in the sea water samples from the Kayindaung in Tanintharyi Coastal Area

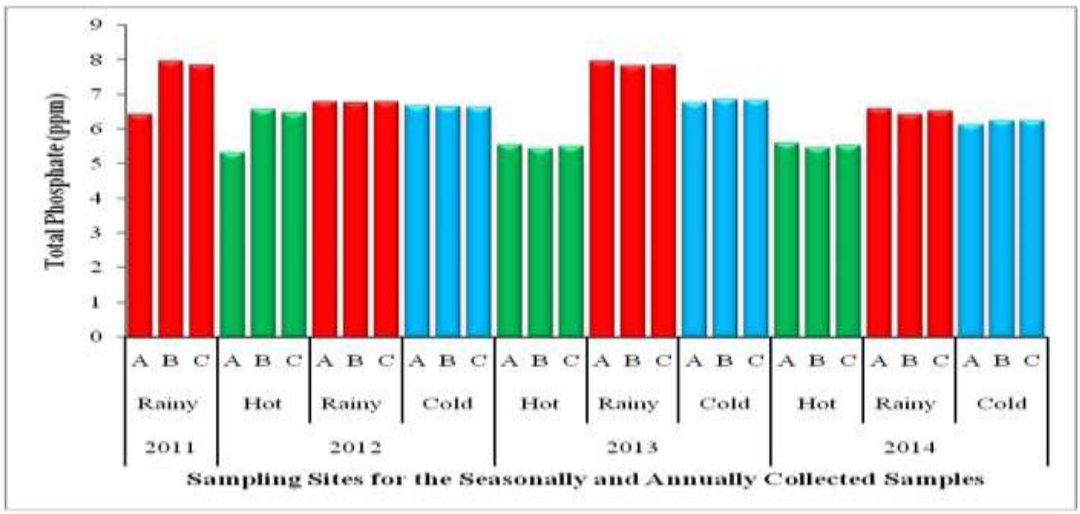

Figure 5 Seasonal changes of total phosphate values in the sea water samples from the Kayindaung in Tanintharyi Coastal Area

Total Nitrogen in Sea Water Samples

Nitrogen refers to all inorganic forms of nitrogen present in water (ammonia, ammonium nitrate and nitrite). Nitrogen concentrations in water can be reported as total nitrogen or as nitrogen in the form that it is present in solution. When nitrogenous organic matter is destroyed by microbiological activity, ammonia is produced and is therefore found in many surface and ground waters. Higher concentrations occur in water polluted by sewage, fertilizers, agricultural wastes or industrial wastes containing organic nitrogen, free ammonia or ammonium salts (Al-Safady, 2012).

In this research, total nitrogen concentration of sea water samples were in the range of 0.660 ppm to 1.320 ppm in rainy season (2011), 0.560 ppm to 0.920 ppm in hot season, 1.218 ppm to 1.425 ppm in rainy season, 0.956 ppm to 1.124 ppm in cold season (2012), 0.822 ppm to 0.992 ppm in hot season, 1.432 ppm to 1.586 ppm in rainy season, 1.185 ppm to 1.235 ppm in cold season (2013), 0.752 ppm to 0.915 ppm in hot season, 1.323 ppm to 1.445 ppm in rainy season, 0.987 ppm to 1.182 ppm in cold season (2014), respectively (Table 3 and Figure 6). The recorded high value (1.586 ppm) of total nitrogen during rainy season (2013) could be due to the organic materials received from the catchment area during ebb tide. The recorded low value (0.560 ppm) during hot season (2012) may be due to its utilization by phytoplankton as evidenced by high photosynthesis activity and the dominance of neritic sea water having a negligible amount of nitrate.

The high concentrations of total nitrogen in sea water causes a phenomenon known as "Eutrophication", which means an excessive growth of the algae in water which consumes the oxygen gas dissolved in water causing the death of fishes in that water.

Table 3 Seasonal Changes of the Total Nitrogen in the Sea Water Samples

Sr No.	Year	Season	Sampling sites	Total Nitrogen (ppm) Mean ± SD
1.	2011	Rainy	A	0.660 ± 0.015
			B	1.200 ± 0.015
			C	1.320 ± 0.020
2.	2012	Hot	A	0.560 ± 0.025
			B	0.780 ± 0.015
			C	0.920 ± 0.021
		Rainy	A	1.339 ± 0.012
			B	1.425 ± 0.012
			C	1.218 ± 0.015
		Cold	A	1.124 ± 0.016
			B	1.058 ± 0.026
			C	0.956 ± 0.022
3.	2013	Hot	A	0.935 ± 0.018
			B	0.822 ± 0.021
			C	0.992 ± 0.018
		Rainy	A	1.586 ± 0.017
			B	1.432 ± 0.020
			C	1.524 ± 0.020
		Cold	A	1.185 ± 0.023
			B	1.235 ± 0.015
			C	1.224 ± 0.018

Sr No.	Year	Season	Sampling sites	Total Nitrogen (ppm) Mean ± SD
4.	2014	Hot	A	0.752 ± 0.012
			B	0.915 ± 0.012
			C	0.832 ± 0.015
		Rainy	A	1.445 ± 0.017
			B	1.323 ± 0.015
			C	1.349 ± 0.022
		Cold	A	0.987 ± 0.012
			B	1.097 ± 0.015
			C	1.182 ± 0.012
EPA Standard (2009)				-
ASEAN Standard (2010)				-

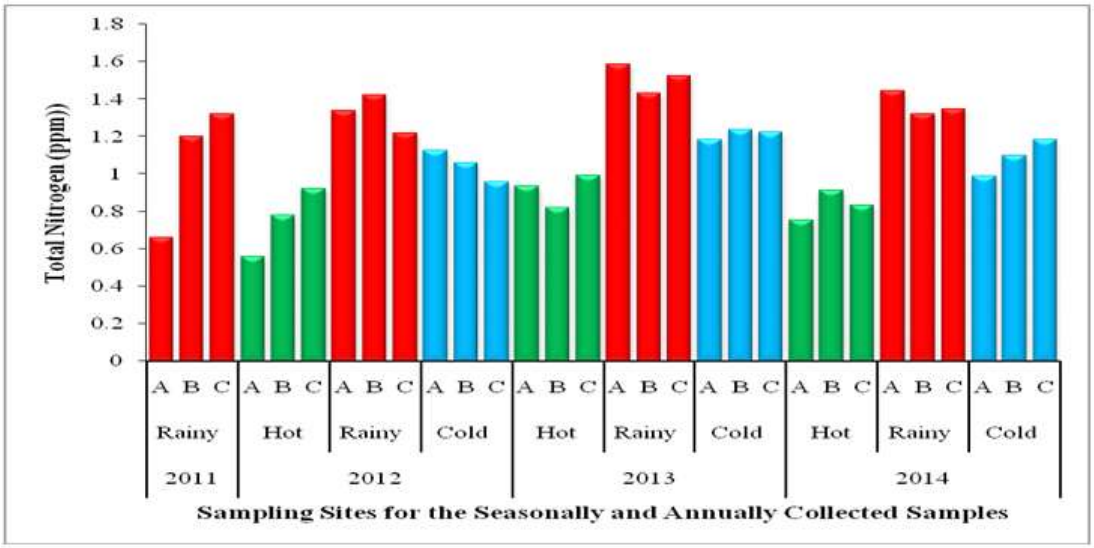

Figure 6 Seasonal changes of total nitrogen values in the sea water samples from the Kayindaung in Tanintharyi Coastal Area

Eutrophication Levels of Coastal Sea Water

Water eutrophication is mainly caused by excessive loading of nutrients into water bodies like nitrogen and phosphorus. Excessive nutrients come from both point pollution such as waste water from industry and municipal sewage, and non-point pollution like irrigation water, surface runoff water containing fertilizer from farmland, etc (Yang, 2008). Although nutrients are essential for the growth and survival of an estuary's plants, an excess of nitrogen and phosphorus may trigger a string of events that seasonally deplete dissolved oxygen (DO) in the water (Ronald and Ohrel, 2006).

In this research work, the eutrophication level of sea water samples were determined by the values of DO, orthophosphate and total nitrogen. From the experimental data of these three values were compared with criteria for evaluation degree of nutrient over-enrichment (Table 4(a)), indicated that which season for sample A, B and C were low-nutrient enrichment (oligotropic), medium-nutrient enrichment (mesotropic) and high-nutrient enrichment (eutropic). For example, in hot season (2012), nitrogen concentrations were in the range of 0.560 ppm to 0.920 ppm (within >0.1 ppm - <1.0 ppm, medium), orthophosphate concentrations were in the range of 0.014 ppm to 0.027 ppm (<0.03 ppm, low) and DO values were in the range of 7.22 ppm to 7.65 ppm (≥ 5 ppm, low). So, the samples A, B and C for hot season (2012) is low-nutrient enrichment (oligotropic).

In the present work, during 2011 to 2014 it was found that all samples for rainy season and cold season were medium-nutrient enrichment (mesotropic) and all samples for hot season were low-nutrient enrichment (oligotropic) for annually collected samples are shown in Table 4(b). So it is satisfied for the protection of aquatic life.

Table 4(a) Criteria for Evaluating Degree of Nutrient Over-Enrichment

Parameters	low	medium	high
Nitrogen (ppm)	≤0.1	>0.1 - <1.0	≥1.0
PO_4^{3-}(ppm)	<0.03	>0.03 - <0.3	≥0.3
DO (ppm)	≥5	>2 - ≤5	0 - ≤2

(Tong and Deocadiz, 1999)

Table 4(b) Evaluation of Nutrient Levels of Sea Water Samples

Sr No	Year	Season	Sampling sites	Dissolved Oxygen (ppm)	Ortho phosphate (ppm) Mean ± SD	Total Nitrogen (ppm) Mean ± SD	Nutrient Enrichment
			A	7.41	0.061 ± 0.003	0.660 ± 0.015	medium**
1.	2011	Rainy	B	7.85	0.123 ± 0.005	1.200 ± 0.015	medium**
			C	7.62	0.184 ± 0.005	1.320 ± 0.020	medium**
			A	7.65	0.014 ± 0.002	0.560 ± 0.025	low*
		Hot	B	7.34	0.018 ± 0.003	0.780 ± 0.015	low*
			C	7.22	0.027 ± 0.003	0.920 ± 0.021	low*
			A	7.83	0.109 ± 0.005	1.339 ± 0.012	medium**
2.	2012	Rainy	B	7.79	0.128 ± 0.003	1.425 ± 0.012	medium**
			C	7.72	0.142 ± 0.002	1.218 ± 0.015	medium**
			A	7.71	0.052 ± 0.003	1.124 ± 0.016	medium**
		Cold	B	7.69	0.043 ± 0.003	1.058 ± 0.026	medium**
			C	7.65	0.046 ± 0.005	0.956 ± 0.022	medium**
			A	7.15	0.029 ± 0.002	0.935 ± 0.018	low*
		Hot	B	7.35	0.032 ± 0.003	0.822 ± 0.021	low*
			C	7.24	0.035 ± 0.003	0.992 ± 0.018	low*
			A	8.11	0.131 ± 0.004	1.586 ± 0.017	medium**
3.	2013	Rainy	B	8.05	0.179 ± 0.005	1.432 ± 0.020	medium**
			C	8.21	0.186 ± 0.005	1.524 ± 0.020	medium**
			A	7.72	0.075 ± 0.004	1.185 ± 0.023	medium**
		Cold	B	7.58	0.063 ± 0.003	1.235 ± 0.015	medium**
			C	7.64	0.078 ± 0.003	1.224 ± 0.018	medium**
			A	7.09	0.033 ± 0.003	0.752 ± 0.012	low*
		Hot	B	6.86	0.034 ± 0.003	0.915 ± 0.012	low*
			C	7.22	0.027 ± 0.002	0.832 ± 0.015	low*
			A	7.99	0.132 ± 0.005	1.445 ± 0.017	medium**
4.	2014	Rainy	B	7.81	0.139 ± 0.004	1.323 ± 0.015	medium**
			C	7.93	0.143 ± 0.005	1.349 ± 0.022	medium**
			A	7.72	0.058 ± 0.004	0.987 ± 0.012	medium**
		Cold	B	7.45	0.045 ± 0.004	1.097 ± 0.015	medium**
			C	7.54	0.039 ± 0.003	1.182 ± 0.012	medium**

* Identified as oligotropic, ** Identified as mesotropic

Conclusion

The values of dissolved oxygen in the course of this research work for all sea water samples were in the slight variation and the range between 6.86 ppm to 8.21 ppm. The measured DO values were within the permissible level of ASEAN standard (> 5ppm).The values of orthophosphate, organic phosphate and total phosphate were found to be in the range of (0.014 ppm to 0.186 ppm), (5.311 ppm to 7.838 ppm) and (5.325 ppm to 7.969 ppm), respectively for both seasonally and annually collected samples. The total nitrogen values in the studied area were found in the range of 0.560 ppm to 1.586 ppm. From the results of water analysis of all sea water samples seasonally and annually indicated that the eutrophication level ranged from low to medium levels. This clearly revealed that the sea water of the studied area is not polluted and aquatic creatures are well protected from DO depletion due to eutrophication.

Acknowledgements

The authors would like to express their profound gratitude to the Department of Higher Education (Yangon Office), Ministry of Education, Yangon, Myanmar, for provision of opportunity to do this research and Myanmar Academy of Arts and Science for allowing to present this paper.

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