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Distribution Of Phytoplankton as Indicators Of Water Quality In The Terengganu Estuary, Malaysia

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Abstract: River mouth is a part of an estuarine system and a boundary of end point of the river flows and a starting point of the ocean, where the dynamic inflows of fresh and salt water that provide high level of nutrients to support aquatic life systems including microscopic plant species such as phytoplankton. Pattern of water quality in estuaries is influenced by the river flow, wastewater discharged and the tidal phenomena for the study area. In order to identify the most dominant group of phytoplankton species and its distribution pattern as indicators of water quality, the Terengganu estuary, Malaysia has been chosen as a study area with an estimated 11.2 km reach towards downstream. A comprehensive data collection has involved a total of ten sampling stations. A series of laboratory tests has been also carried out to identify the phytoplankton species and to analyst the density of the phytoplankton. The results of the analysis show that there are six types of phytoplankton were successfully identified, namely: Euglenophyta (Euglenoids), Bacillariophyta (Diatoms), Chlorophyta (Greenalgae), Cyanophyta (Blue - greenalgae), Pyrrophyta (Dinoflagellates) and Chrysophyta (Chrysophytes). Results have found out that most of the phytoplankton is more abundant in the southern part of the coastal area compared to the Northern part and estuary area with the 49 % of Diatoms and 42 % of blue - green algae respectively were successful identified as the most dominant of the phytoplankton in the Terengganu estuary. Canberra Metric method has been applied, which is much simplified in data analysis and interpreting process especially on the temporal variation of phytoplankton data. It also shows that diatoms, blue-green algae and Dinoflagellates likely to have strong relationship in occurrence of the TOC, Nitrate, Dsi and TDN. On the other hand green-algae, Chrysophytes and Euglenoids are strongly in relationships with the occurrence of the Nitrate, DSi, TSS and clorofil-a.

Keywords: Terengganu estuary, nutrient, phytoplankton, water quality, temporal variation, Canberra Metric

1. Introduction

Estuary is a partially enclosed coastal body of water that is connected to the open sea by one or more rivers or streams flowing into it, and the seawater in it is being diluted measurably by the freshwater flowing from the land discharge (Pritchard, 1967; Harvey J. et. al., 1998). It is also a transition zone between river and maritime environments; and is subjected to both marine influences: tides, waves, and the influx of saline water and also riverine influences; i.e. flows of fresh water and sediment. Because of their active zones (tidal fluctuations) that provide high levels of nutrients in both the water column and sediment, this has made estuary among the most productive natural habitats in the world (McLusky and Elliott, 2004).

In recent decades, however, population growth and related activities from point and non-point source of various agricultural practices, wastewater and sewerage treatment plants, urban runoff, industrialization, commercial agricultural plantation, nutrient enrichment in the freshwater and marine coastal systems, have speeded up the nutrient inputs to higher levels that change the natural occurrence either in spatial or temporal (Thompson, 1998; Fisher et al., 1999). Excess of spatial and temporal nutrients discharged to water body such as nitrate-nitrogen, total nitrogen and phosphorus may cause eutrophication which subsequently promotes algal-bloom and a variety of other negative impacts (Suzanne Bricker et. al., 1999). Dugdale et al., 1995; Boyd et al., 1999; De Baar et al, 1999; Wu and Chou, 2003 also found silicon as an important compositional element in diatoms, also potentially limit a new production either in the open ocean, coastal waters or estuaries.

Phytoplankton is the microscopic plants or called algae that drift around on the oceans' currents and are abundant in the surface waters where sunlight and nutrients are sufficient for photosynthesis process. These microscopic plants are very important as they are the earliest to form the base of the oceans' food chain (Dixit et. al., 1999), major contribution to ocean productivity (i.e. up to 50% of the oxygen) such as diatoms (Tiffany, 1968; NASA, 2005), which are useful as oil storage pockets (Prescott, 1968) while some of the species such as Spirulina sp. produce multi-nutrition supplement (Vonshak, 1997). Other than its benefits, some phytoplankton are also toxic and may cause paralytic shellfish poisoning (PSP) especially when the toxic of Dinoflagellates sp. that is found in seafood during the 'red tides' phenomenon. This

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toxicity can cause tongue or lips to become numb, unable to control the body movement, vomit and also cause respiratory paralysis mechanism that can cause death within a few hours (Eleanor Ely and Neil Ross, 1989; Coleman et. al, 1986).

The purpose of this study is to identify phytoplankton group and its distribution pattern in relationship with the existing surface water quality (i.e. 0.5 m below surface) at the Terengganu estuary. To investigate the relationship of surface water quality with the existence of the phytoplankton, nine chemical parameters had been retrieved and while six types of phytoplankton were successfully identified, namely: Euglenophyta (Euglenoids), Bacillariophyta (Diatoms), Chlorophyta (Greenalgae), Cyanophyta (Blue-greenalgae), Pyrrophyta(Dinoflagellates)and Chrysophyta (Chrysophytes). On the other hand, Canberra Metric Method has been used for biological data analysis on the temporal variation of phytoplankton data and on the distribution pattern.

1.1 MATERIALS AND METHODS

Study Area and Data Collection

The study has been carried out at the Terengganu estuary and the objective is to determine the pattern of the spatial data collected on its surface water at 10 locations in the estuary area. Second objective to be considered is from the retrieved data, the much desired method to analyse the distribution of the phytoplankton is by using the Canberra Metric. All results obtained from this method need to be interpreted in terms of the statistical relationship of phytoplankton group and the surface water chemical parameters.

As regards to 2010 annual report of Department of Environment (DOE), Drainage dan Irrigation Department (DID), upstream of the Terengganu River was classified as class II , while Nerus River was classified as class III. Having class II water quality, the upstream of Terengganu River still have its rare aquatic lives such as terrapins, Baung and Patin, it is much considerate with (DID, 2010). Water samples were taken on 5th Mac 2012 involving ten stations: station S6 to S15. Nine of the chemical parameters considered from the samples are Total Suspended Solid (TSS), Chlorofil-a, Dissolve Silicate (DSi), Total Dissolve Nitrogen (TDN), Ammonia, Total Organic Carbon (TOC), Dissolve Phosphorus (DIP), Nitrite and Nitrate. These parameters are useful to do some observation on the relationship of the organism presence such as phytoplankton.

Besides carrying out water sampling works, ten samples of the phytoplankton are also taken into consideration for every point. These samples were taken using a phytoplankton net and preserved in plastic bottle using the phytoplankton preservation. Completed collection samples were then sent to the laboratory and phytoplankton samples were analyzed under microscope to indentify the species.

Water Quality Map and Canberra Metric Method

For data management, all collected data will be classified accordingly to the zones area and the zones are divided into three: river, coastal and offshore. Then the map of the water quality on surface water are produced using ArcGIS software to analyse the 2D view of an existence chemical properties. To simplify the analyses of spatial phytoplankton data, calculations for constancy and abundant values using Canberra Metric method are determined based on the maximum value that of 100%. Canberra Metric used in this study is much helpful for biological data analysis and interpreting process especially on the temporal variations of phytoplankton data and find the idea on the distribution pattern. The higher constancy value for each species of station in zoning area will indicate that an identified species exist or mostly exist. Then all the constancy and abundance density are converted into grade system, i.e. from grade 1: exist to grade 5: very variations. The details of the grading are in Table 1.

Grade	Occurrence (%)	Definition of Grade	Abundance
1	0-20	Occur	0-625
2	21-40	Normal	626-1250
3	41-60	Moderate	1251-1875
4	61-80	Varied	1876-2500
5	81-100	Most varied	>2500

Table 1: Grading form for occurrence of phytoplankton in Terengganu estuary

Data Analysis

Coincidence of occurrence is the probability of two or more groups to happen more than 50% in every zone (Mathis, 1991). Results in coincidence and abundance are very difficult to observe because it involves lots of data and is difficult to interpret or to compare with other data within origin with different locations. To simplify the data analysis, the coincidence and abundance results need to be converted into matrices according to the zoning and species. Then occurrence or correction will be made in the data calculations to avoid the bias of the distribution pattern. Converting the occurrence values are the most important stage in Canberra Metric as the grading form will be enable the data into less complicated. The phytoplankton distribution relationship are analyzed and then presented in the form of simple bar graph for easy interpretation.

RESULTS AND DISCUSSION

Retrieved water surface data from YSI multi-probe are processed using ArcGIS to produce the water quality observed map (see Figure 1) especially to analyze the abundance of the nine chemical parameters as measured. Analysis on measured water quality data indicates that seven of water quality data dominate the river zone namely: Ammonia, Nitrite, Total Dissolve Nitrogen (TDN), Dissolve Inorganic Phosphorus (DIP), Total Organic Carbon (TOC), Nitrate and Dissolve Silicate (DSi) while coastal zone is dominate by TSS. Even though Nitrate and DSi are found in the river, it also found in the offshore area with the Clorofil-a.

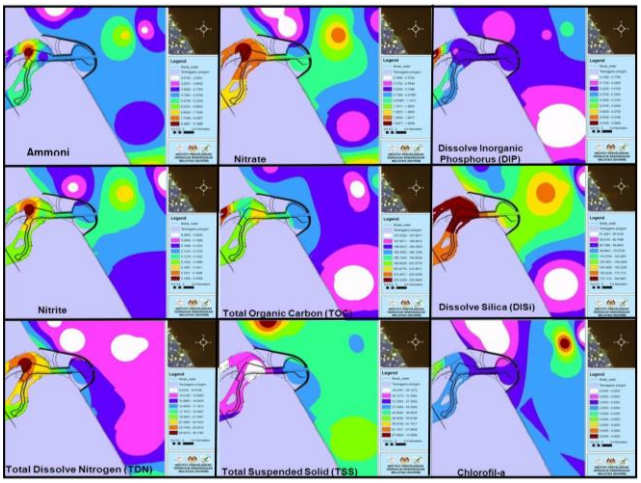

Figure 1: Map of 2D are create to analyst the surface water quality data

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To simplify the analyses of Canberra Metric, data for constancy and abundance values are determined based on the maximum value. Highest constancy value for species in the zoning area are taken as 100% for all three zones and considered as all six identified species are exist in
every sampling location in each of zone area: river, coastline and offshore (see Figures 2 to 4). However the maximum abundance value for each species that has been analyzed for every zone area varied. Among the all zones, the highest abundance value of phytoplankton is Oscillatoria sp. ¢ with 1650.5 cells/mL in the coastline zone, 638.3 cells/mL in the offshore and 243.3 cells/mL river zone.

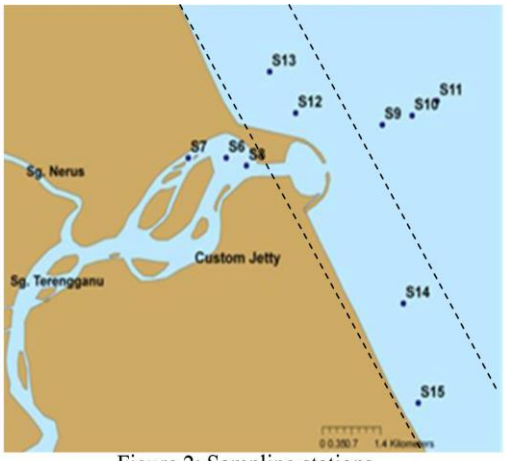

Figure 2: Sampling stations

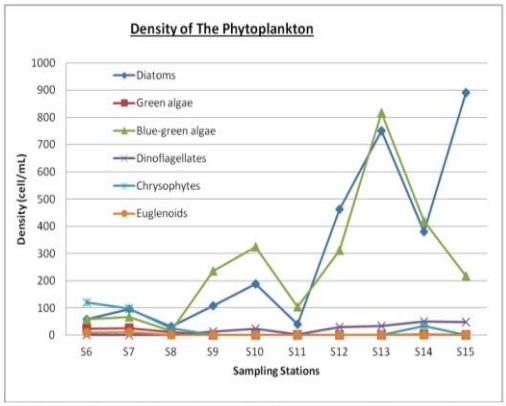

Figure 3: Density of the phytoplankton according to the station

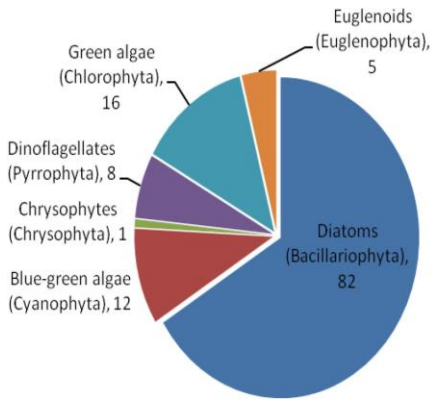

Figure 4: Quantity of phytoplankton in Terengganu estuary

Analyses on the distribution measurement indicated that none of the phytoplankton group reached the highest coincidence value of 100%. Thus, this distribution pattern for species of each sampling zone is not uniform. Higher occurrence value for density is dominated by diatoms in all zones. A relationship between widespread and abundance value proves that even though occurrence value is lesser than the maximum value selected, some of abundance values reflect a particular species group is also high. The non-uniformity relationship is also applied in this study and the results show the coincidence value of Chrysophytes and Blue-green algae are lower than 15.45% of Diatoms, both groups have higher abundance value with 243.3 cells/mL and 660.2 cells/mL respectively compared to Diatoms with only 337.6 cells/mL (see Table 2).

Table 2: Distribution of the Phytoplankton at Terengganu River

	Density Occurance, %								
	River			Coastline			Offshore		
Phytoplankton Group	%	Abundance (cells/mL)	Grade	%	Abundance (cells/mL)	Grade	%	Abundance (cells/mL)	Grade
Bacillariophyta (Diatoms)	**11.79**	179.4	1	**19.21**	**2540.4**	5	**15.45**	337.6	1
Chlorophyta (Green-algae)	6.50	64.3	1	0.30	1.8	1	0.00	0	1
Cyanophyta (Blue-green algae)	4.47	144.8	1	0.91	1721.6	3	1.22	**660.2**	2
Pyrrophyta (Dinoflagellates)	0.41	0.3	1	2.44	161.8	1	2.03	36.8	1
Chrysophyta (Chrysophytes)	0.41	**243.3**	1	0.30	32.9	1	0.00	0	1
Euglenophyta (Euglenoids)	2.03	20.8	1	0.00	0	1	0.00	0	1
Maksimum Value	**11.79**	**243.3**	1	**19.21**	**2540.4**	5	**15.45**	**660.2**	2

It is found that diatoms, blue-green algae, dinoflagelates may adapt with the occurrences of the ammonia, nitrite, DIP, Grading form (see Table 1) can simplify the occurrence and directly explains the distribution of phytoplankton group specifications based on zoning sampling or group richness. The lowest level of the species richness or density graded as 1 if the number of species for each group in a sampling zone is from 0% to 20% for abundance value of 0 to 625 cells/mL. While the high level of the density represented by the number 5 with coincidence of 81-100% and the abundance value from collected sampling is more than 2500 cells/mL species.

Referring to Table 2, the relationship between grades with occurrence and abundance clearly indicate that grade 5 based on occurrence are 18 times lesser than the abundance as it record only one time. According to the water quality map (see Figure 2), the relationship of the parameters and the phytoplankton group indicates that most of the phytoplankton groups are present in the river zone with an occurrence of seven parameters namely ammonia, nitrite, TDN, DIP, TOC, Nitrate and DSi. Meanwhile, the occurrence of the higher TSS content with 74 mg/L at the coastline zone, shows that the diatoms and cyanophyta groups are tolerantly varied and moderately distributed respectively. The area which is dominated by cyanophyta group is due to the occurrence of Chlorofil-a, DSi and Nitrate while the other five phytoplankton groups are considered to exist in all zones.

Analysis on the retrieved surface water data indicate that ammonia content is relatively high with 8.4-9.2uM in river zone and not suitable for fish in this area as it may affect the metabolism of the body, nervous system' and death of the aquatic life (Eleanor Ely and Neil W. Ross, 1989; Coleman et. al., 1986). Analysis also show that diatoms, blue-green algae

and Dinoflagellates likely to have strong relationship in occurrence of the TOC, Nitrate, Dsi and TDN. On the other. hand, the analysis shown that green-algae, Chrysophytes and Euglenoids have in significant relationships with the occurrence of the Nitrate, DSi, TSS and clorofil-a in the Terengganu estuary.

CONCLUSIONS

It is found that ammonia content in the river zone and estuary is relatively high and hazard to the surrounding area. Method of analyses data using Canberra Metric has indicates that occurrence of the TOC, Nitrate, DSi and TDN may not a suitable medium condition for the green-algae, Chrysophytes and Euglenoids to adapt. On the other hand, occurrences of the Nitrate, DSi, TSS and clorofil-a have prepared the unsuitable medium condition for the diatoms, blue-green algae and Dinoflagellates. All analyzed phytoplankton groups show that their distributions are varied even though they are considered occur in all zones, with diatoms is the most varied sampling and abundant. The occurrences of the water chemical properties in all zones indicate that these parameters do have a significant relationship with the phytoplankton groups even though the occurrence is small. From the study, it is useful to identify the quality of the water as indicator in the area based on species occurrence and distribution of the phytoplankton species. It is strongly recommended to use the Canberra Metric in future detail studies because of its convenience for easier biological data analysis and interpreting process especially on the temporal variations of data.

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