Comparative Seasonal analysis of physiochemical parameters and phytoplankton species composition in Batticaloa lagoon and Negombo lagoon

Sathananthan.S.

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Abstract:

Batticaloa Lagoon is a very large estuarine lagoon in Batticaloa District, Eastern Sri Lanka. The city of Batticaloa is located on land between the lagoon and the Indian Ocean. Batticaloa district is flourished with three lagoons, such Batticaloa lagoon, Valaichchenai Lagoon and Vakari Lagoon. Among them, Batticaloa lagoon is the largest lagoon in Batticaloa District. Batticaloa lagoon is a long and narrow lagoon situated in the east coast of Sri Lanka with the total area of approximately 11,500 ha of water.

Negombo lagoon is essentially a **semi-enclosed** open water body between the **sea** and a **river** delta. It is mixing ground not only for sea water coming in through the tidal inlet freshwater entering through the river delta but also for dissolved inorganic and organic constituents, and particulate matter, sediment and biomass. Therefore its physical nature, chemical composition and biological diversity are always determined by the diurnal and seasonal tidal activity and the catchment induced freshwater inflow. The lagoon is fed by a number of small rivers and a canal. It is linked to the sea by a narrow channel to the north, near Negombo city. It is surrounded by a densely populated region containing rice paddies, coconut plantations and grassland. The land is used for fishing and agriculture

The research work started in January and water samples were collected in January and February and due to the prevailing situation about COVID-19 the collection of water samples were blocked. Then the water samples were collected in June. Based on the analysis of species diversity and species composition there was a far variation when compare to the species composition in different months specifically between January and June.

Cyanobacterial composition was highly reduced and Diatoms and Desmids were increased which means the water body become fresh and the pollution level was highly reduced.

Phytoplankton used as bio Indicators and predictable about the quality of water.

Index Terms: *Phytoplankton, algal bloom, physio-chemical, genus, species diversity, species density, species composition, estuary, sand bar, streams, taxa, euphotic zone, protists, cyanobacteria, photosynthetic bacteria*

1. Introduction

1.1. Phytoplankton

Phytoplankton are microscopic, plant-like organisms that grow abundantly in the seas and oceans. Much like land-based plants, phytoplankton require sunlight, water and nutrients for growth. They get their green color from chlorophyll which also allows them to perform photosynthesis, creating their own food from sunlight and carbon dioxide. Phytoplankton live near the ocean's surface, where they obtain sunlight and depend on upwelling deep ocean currents to provide nutrients. There are also freshwater phytoplankton living in lakes, ponds and rivers.

Phytoplankton are a type of microscopic plankton capable of photosynthesis found in oceans, seas, and freshwater, and an essential component of aquatic ecosystems. Phytoplankton can range in size and shape, and since they are photosynthesizing autotrophic organisms, they inhabit waters exposed to sunlight. Although each organism is microscopic, in sufficient numbers, phytoplankton can be observed as colored patches at the surface of bodies of water, or where two currents meet, due to the presence of chlorophyll. Phytoplankton are often cultured to support aquaculture, and are critical for controlling carbon dioxide and oxygen levels in the Earth’s atmosphere since the Precambrian Era. Indeed, it is estimated that phytoplankton are responsible for as much as 85% of the oxygen in the atmosphere.

The phytoplankton consist of a very large number of species in spatially and temporally dynamic assemblages. The availability of physical transport mechanisms (dispersal limitation), biological traits (growth rate, functional type, physical and chemical requisites) and biotic interactions (competition, predation) determine the local occurrence of varying subsets of the regional pool of species. In upwelling systems, different phytoplankton species use different mechanisms or functional strategies (e.g. mixotrophy) that allow them to take advantage of the multiple niches arising from the ever changing conditions in turbulence, temperature light and nutrient availability (Lamont T, Barlow RG, Kyewalyanga MS., 2014)

Upwelling favorable winds are usually seasonal, but pulse episodes as short as one day or extending for several weeks at a time (Dorman CE, Winant CD., 1981-1990) may occur all year-round. With a life-cycle timescale of days, phytoplankton responds rapidly to the physical disturbance and changing nutrient regimes induced by upwelling episodes even at the shorter scale (Estrada M, Blasco D., 1985) the flux of nutrients regulates succession, while the frequency of water column destabilization is important for resetting the assemblage to early successional stages (Margalef R., 1978).

In the subtropical water bodies, by contrast, phytoplankton populations drop off in summer. As surface waters warm up through the summer, they become very buoyant. With warm, buoyant water on top and cold, dense water below, the water column doesn't mix easily.

Phytoplankton are primarily dependant on minerals found in aquatic environments and Vitamin B to survive. For aquatic environments to support phytoplankton, the presence of iron, phosphate, silicic acid, and nitrate are required. Indeed, when there is a deficiency in these macronutrients, there is a corresponding absence of phytoplankton.

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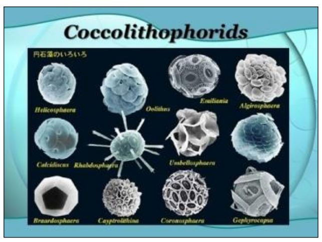
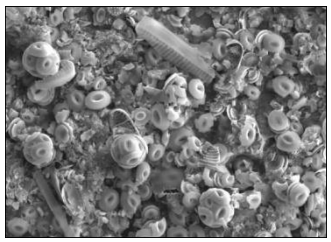
1.2. Some of the examples of Phytoplankton

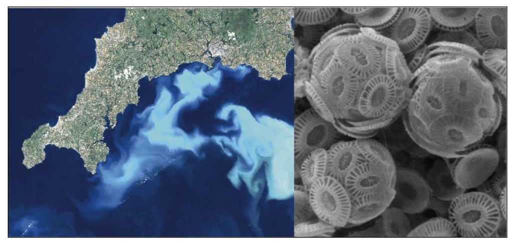
Since the term **phytoplankton** encompasses a wide variety of different photosynthesizing aquatic microorganisms (over 5000 species were recorded), different species are found in each **specific environment**. Some of the most common species are given below:

Coccolithophorids

Coccolithophorids are an important species of phytoplankton that exhibit characteristic calcium carbonate plates known as coccoliths. Although this type of phytoplankton is an important **microfossil,** it is also a source of **dimethyl sulfide**, which is thought to represent a potential mechanism by which to regulate **climate change**. It is thought that by increasing the number of these phytoplankton, the enhanced level of dimethyl sulfide will become oxidized, forming sulfur dioxide and sulfate aerosols. These aerosols will function as **cloud seed nuclei** that will increase **cloud coverage** and the reflection of sunlight.

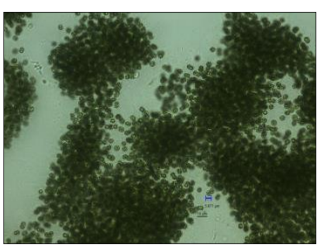



Deep Sea sediments and Microfossil

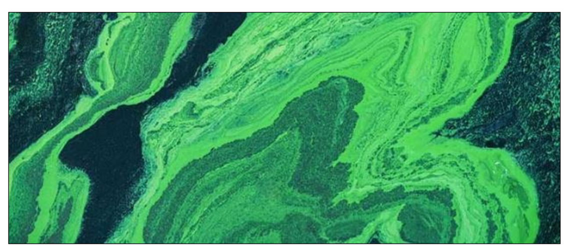

Coccolithophores sediments

Cyanobacteria

Cyanobacteria are extremely small phytoplankton that typically inhabit less turbulent waters and can thrive in environments where there are fewer nutrients available. Cyanobacterial species are highly diverse and have been shown to be extremely tolerant to changes in aquatic conditions, thus outcompeting many other types of phytoplankton when water temperatures change or nutrients become less abundant.


Microcystic


Anabaena


Cyanobacteria Bloom

Diatoms

Diatoms are an extremely important phytoplankton that while microscopic, replicate rapidly. Diatoms can be used as an indication of water quality, as they follow a “bloom-and-bust” life cycle. As nutrients reach the sunlight surfaces of an ocean, diatoms rapidly reproduce. When the nutrients are depleted (i.e., silicon), this growth ceases. Diatoms also comprise a substantial portion of the organic matter found in the sediment of large bodies of water.

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Diatoms

Diatom sediments at the bottom of the waterbed

Dinoflagellates

Dinoflagellates are an important phytoplankton typically involved in supporting coral reef ecosystems as a significant food source for many species. Dinoflagellates are known to cause harmful algal blooms (HAB) exhibiting a characteristic red color, termed **"red tide".** Such blooms have been known to contaminate shellfish, which will cause food poisoning in humans, if consumed.

Freshwater Dinoflagellates

Marine Dinoflagellates

Dinoflagellate Red-Tide

1.3. Why are they important?

The importance of phytoplankton is due largely to their place at the base of the marine food chain. Small fish and some larger species of fish and whales consume phytoplankton as their main food source. These fish then become prey for larger fish and marine mammals on up the chain. Dead phytoplankton fall to the bottom of the ocean and nourish shellfish and other bottom dwellers. Crashes in the phytoplankton population can have serious ramifications for the entire marine ecosystem. Variances in the phytoplankton population can be an indicator of other ocean problems, such as excessive pollution.

Global climate health is affected by phytoplankton population health. Phytoplankton is responsible for approximately 50 percent of all photosynthesis on Earth. This means they function as a major carbon dioxide sink, pulling the gas from the atmosphere and emitting oxygen in its place. In this way the phytoplankton population is a major factor in limiting **global warming** and in the general **atmospheric health** of the planet.

The importance of plankton doesn't stop in the water. The health of the human population is directly related to the health of the oceans and the climate. Certain species of fish that consume phytoplankton, such as sardines, serve as a food source both for humans and larger fish. Many communities worldwide depend on commercial fishing both for nourishment and employment. Without phytoplankton, the fish population and therefore commercial fishing

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would disappear. Anthropogenic activity will also be impacted in many ways by global warming, and phytoplankton's key role in this process makes them critical to our survival.

Concerns have been raised by scientists that the hole in the ozone layer could have negative impacts on the phytoplankton population, as harmful rays from the sun could kill them. Phytoplankton are also harmed by pollutants in the ocean, such as agricultural and industrial runoff, and are often absent where pollutant concentrations are high. Nourished by nutrients welling up from the ocean floor and iron deposited on the ocean's surface by the wind, phytoplankton are at risk from changes in global climate and wind patterns. Winds drive the current upwelling which nourish the phytoplankton and also carry required minerals to the ocean. Dust from drier climate conditions can limit the sunlight and hurt the ability of phytoplankton to perform photosynthesis and survive.

Phytoplankton are critical to other ocean / lagoon / lake biogeochemical cycles, as well. They take up, transform, and recycle elements needed by other organisms, and help cycle elements between species in the ocean / lagoon. Photosynthetic bacteria are especially important in the nutrient-poor open water bodies, where they scavenge and release scarce vitamins and other micronutrients that help sustain other aquatic life.

Some phytoplankton have a direct impact humans and other animals. Dense blooms of some organisms can deplete oxygen in coastal waters, causing **fish** and **shellfish** to suffocate. Other species produce **toxins** that cause can cause **illness** or **death** among **humans** and even **whales** that are either exposed to the toxins or eat shellfish that accumulate toxins. Such harmful algal blooms (HABs) cause significant economic loss every year in the seafood industry and in tourist communities, and scientists are working to understand the causes of these blooms and to devise ways to predict and prevent them.


HAB cause - Whale kill


Fish kill


Shellfish Kill

1.4. Phytoplankton as Bio-indicator

Phytoplankton plays a central role in the structure and functioning of freshwater ecosystems. They are a significant component of water ecosystems as primary producers (Ligeza & Wilk-Woźniak, 2011). Phytoplankton populations are well-known to be influenced by space-time variations in hydro-chemical and physical parameters (UNESCO, 1981; Cloern et al. 1989). Most of aquatic ecosystems receive several types of inputs including; urban, industrial and thermal effluents and agricultural run-off (Perin, 1975; Collavini et al. 2001). Therefore, Continuous monitoring of aquatic ecosystems is essential to distinguish the effects of human-induced and stressors from natural patterns of ecologic variations.

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The expression 'Bioindicator' is used as an aggregate term referring to all sources of biotic and abiotic reactions to ecological changes. Instead of simply working as gauges of natural change, taxa are utilized to show the impacts of natural surrounding changes, or environmental change. They are used to detect changes in natural surroundings as well as to indicate negative or positive impacts. They can also detect changes in the environment due to the presence of pollutants which can affect the biodiversity of the environment, as well as species present in it (Walsh 1978Walsh GE. 1978).

Toxic effects of pollutants on plankton. In: Butler GC, editor. Principles of ecotoxicology. New York (NY): Wiley. Chapter 12; p. 257–274. Peterson 1986Peterson WT. 1986. The effects of seasonal variations in stratification on plankton dynamics in Long Island Sound. In: Bowman MJ, Yentsch CM, Peterson WT, editors. Tidal mixing and plankton dynamics. Berlin: Springer-Verlag. Vol. 17 Lecture Notes in Coastal and Estuarine Studies; p. 225–319. doi:10.1007/978-1-4612-4966-5_11.; Gerhardt 2002Gerhardt A. 2002.

Bioindicator species and their use in biomonitoring. Environmental monitoring I. Encyclopedia of life support systems. UNESCO ed. Oxford (UK): Eolss Publisher. ; Holt & Miller 2010Holt EA, Miller SW. 2010. Bioindicators: using organisms to measure environmental impacts. Nature. 3(10):8–13. The condition of the environment is effectively monitored by the use of Bioindicator species due to their resistance to ecological variability.

1.5. Batticaloa Lagoon

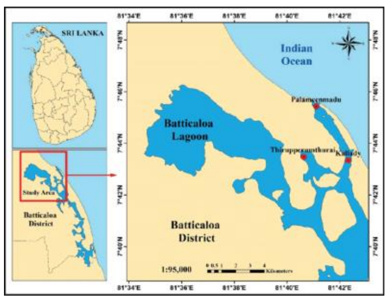
Batticaloa Lagoon is a very large estuarine lagoon in Batticaloa District, Eastern Sri Lanka. The city of Batticaloa is located on land between the lagoon and the Indian Ocean. Batticaloa district is flourished with three lagoons, such Batticaloa lagoon, Valaichchenai Lagoon and Vakari Lagoon. Among them, Batticaloa lagoon is the largest lagoon in Batticaloa District. Batticaloa lagoon is a long and narrow lagoon situated in the east coast of Sri Lanka with the total area of approximately 11,500 ha of water.

Batticaloa lagoon is 56 km long. This lagoon extends from Pangudaveli (Batticaloa district) in the north to Kalmunai (Ampara district) in the south. My study areas Palameenmadu and Kallady bridge area are located at in-between Pangudaveli and Kalmunai. This lagoon opens into the sea at two points. One in the southern end of the lagoon at Periyakallar and the other is midway of the lagoon at Palameenmadu which is close to the Batticaloa town. Both are narrow and approximately 200 m wide. The width of the water flow at their openings varies with the seasons. During the dry season the width of the bar mouth of the lagoon decreases and gradually it get closed with the onset of the north east monsoon which piles up the sand bar by the end of dry season. Later with the rains and with the lagoon mouth closed. The lagoon is fed by a number of small rivers. It is linked to the sea by a two narrow channels, one at Batticaloa and the other at Periyakallar. During the dry season these channels are blocked by sand bars.

Barmouth at Palameenmadu, Batticaloa lagoon opened during rainy season

Bar mouth at Periyakallar, Batticaloa lagoon opened during rainy season

The lagoon is surrounded by a densely populated region used for cultivating rice, coconut and other crops. The surrounding land is used for shrimp farming and rice cultivation. The lagoon has extensive mangrove swamps and some sea grass beds. The lagoon attracts a wide variety of water birds.

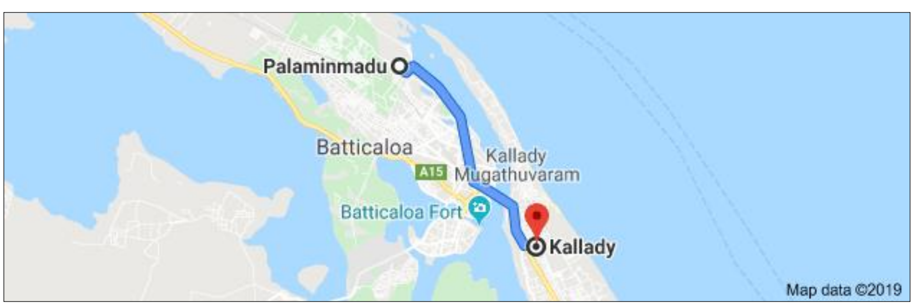


Batticaloa lagoon map

Mangrove swamp at Palameenmadu, Batticaloa lagoon

Palameenmadu, Batticaloa lagoon

Kallady bridge area

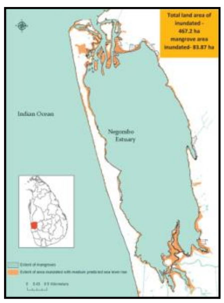


Distance between Palameenmadu to Kallady is 5.52 km

Rainfall in Batticaloa is experienced mostly during the **Northeast monsoon** period from **December** to **February**, caused by the formation of low-pressure systems, depressions and tropical cyclones in South Bay of Bengal. Nearly 52 per cent of the mean annual rainfall occurs during this period. Only 9 per cent of the annual rainfall occur during the first inter monsoon months of **March/April**, and 27 per cent during the second inter monsoon months of **October/November**. Due to the convective thunderstorms that develop between **April** and **October** near drought conditions prevails over the area during the five months of **Southwest monsoon,** where only 12 per cent of the annual rainfall occur.

1.6. Negombo Lagoon

Negombo lagoon is essentially a **semi-enclosed** open water body between the **sea** and a **river** delta. It is mixing ground not only for sea water coming in through the tidal inlet freshwater entering through the river delta but also for dissolved inorganic and organic constituents, and particulate matter, sediment and biomass. Therefore its physical nature, chemical composition and biological diversity are always determined by the diurnal and seasonal tidal activity and the catchment induced freshwater inflow. The lagoon is fed by a number of small rivers and a canal. It is linked to the sea by a narrow channel to the north, near Negombo city. It is surrounded by a densely populated region containing rice paddies, coconut plantations and grassland. The land is used for fishing and agriculture.



Negombo lagoon map

Negombo lagoon by air

Of the 45 brackish water bodies found along the coast of Sri Lanka, the Negombo lagoon plays an important role with respect to shellfish and fin fish fishery. The Negombo lagoon is commonly known as the **"Blue lagoon"** because of the colour of its water during early summer. Being located in the western province, 32 km north of Colombo, and this lagoon has been subjected to a variety of activities including scientific research. In October 1990 an unusual mortality of fish was observed in the Ja Ela, an artificial canal constructed for flood control at the downstream of the Attanagalu Oya. This canal intermittently receives industrial waste from the Ekala industrial city.

The morning panorama of the fishing port in Negombo lagoon, the light haze over the green islands, covered with mangroves.

Big fish harvest (import Japan), Fishing port, Negombo lagoon.

In Negombo lagoon water becomes warmer from **February to April**. The water temperature **dropped slightly** in **May** with the onset of the **southwest monsoon rainfalls** (Silva, 1987). The

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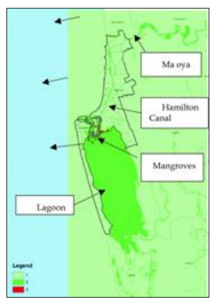
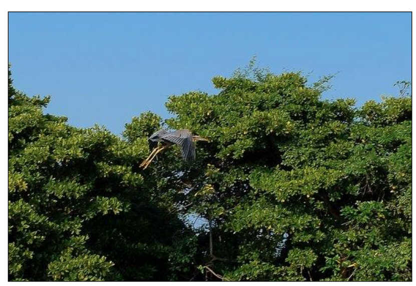
rainfall shows an inter-monsoon dominant pattern in the area, which is characteristic for the northern part of the wet zone of Sri Lanka. The hydrographic studies conducted by the National Aquatic Resources Agency (NARA) in 1992 showed that evaporation exceeds rainfall only from **January to March**. In all the other months there was an excess of rainfall. The highest excess of rainfall occurred over evaporation in **May and October**, and the lowest in **August.** Accordingly **February, July** and **August** are relatively dry month while **April, June September, October,** and **November** could be considered as relatively wet months of the year.

The lagoon has extensive **mangrove swamps** and attracts a wide variety of water birds including cormorants, herons, egrets, gulls, terns and other waders. Negombo, Katunayake, Seeduwa are some nearby towns. Lagoon fishing is popular among the fishing community in Negombo. Lagoon crabs and lagoon prawns are in high taste and demand. Negombo lagoon is characteristic in having islands covered with mangroves at the mouth and an associated major river, Dandugam Oya, at the distal end to the south. A qualitative analysis of plankton was carried out over a period of 12 months by monthly sampling. The diversity and distribution of phytoplankton were studied with special reference to the influence of selected physicochemical parameters namely salinity, water temperature, pH, conductivity, depth total phosphate, nitrate and chloride.



Mangrove fringed Negombo Lagoon with a brush pile (athu kotu). Brush piles attract fish and the owners harvest them periodically.



Negombo lagoon bird spotting

During the sampling period rainy and dry season, salinity ranged between 0.1 and 20.4, water temperature between 26.2°C and 31.8°C and depth between 2.7m and 1.2m.

Occurrence and distribution of plankton were found to be mainly influenced by the salinity gradient along the long axis of the lagoon, which in turn was influenced by the tides and the rainfall. The salinity gradient along the longitudinal axis of the lagoon was established because of the **tidal influence** at the mouth of **proximal end** and the **river flow** at the **distal end**. Higher salinities in the lagoon mouth were preferred by most of **marine species** whereas lower salinities

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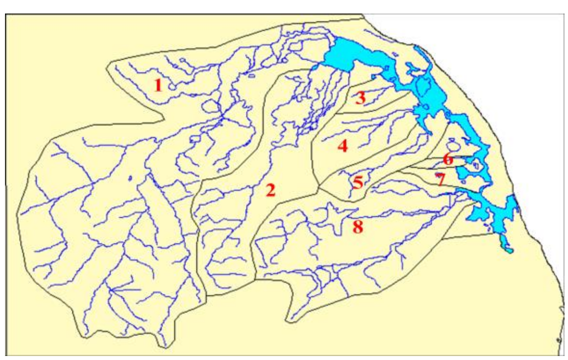
at the distal end of the lagoon were preferred by **freshwater species**. A positive relationship is observed between the number of species recorded and the salinity of the lagoon. A **higher number of species** were recorded near the lagoon mouth than at the **river mouth**. The number of species recorded was **low** during the **rainy months**.

Negombo lagoon-permanently open, locationally stable inlet: Type 1 (left), Kalutara lagoon-permanently open, alongshore migrating inlet: Type 2 (middle), Maha Oya riverseasonally/intermittently open, locationally stable inlet: Type 3 (right). The red dotted circles indicate inlet location. (Duong et al., 2017). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2. Objective

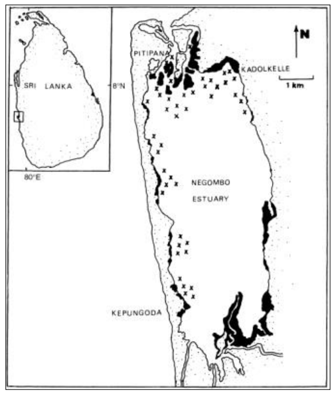
Many studies indicated that phytoplankton population in water bodies oscillate quantitatively as well as qualitatively depending on the quality of waters they receive through the surface runoff of the catchments. Therefore, depending on the water quality changes, their use as indicator organisms has become very important (Durairathnam, 1963).

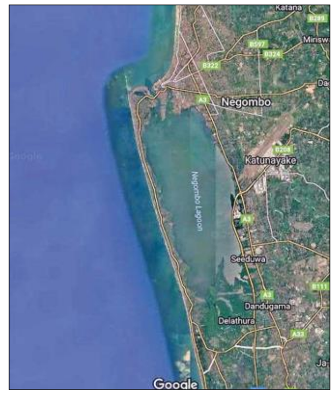
Batticaloa lagoon receives waters from eight rivers which are Mundani River, Magalavettuvan River, Vett River, Pathathe River, Mandipattu River, Namakada River, Thumpankeni River, and. Andella River. The water quality of the lagoon gets deteriorated due to the activities of the catchments. The Physical, chemical and biological properties of the lagoon water during monsoon rains & dry seasons were estimated.



1. Mundani River, 2. Magalavettuvan River, 3. Vett River, 4. Pathathe River, 5. Mandipattu River, 6. Namakada River, 7. Thumpankeni River, 8. Andella River

The Negombo lagoon, one of the most productive brackish water bodies in Sri Lanka is situated in the western province. The Negombo lagoon links with the open sea at its northern mouth and receives freshwater from the Attanagalu Oya, which empties as the Dandugam Oya and the Ja Ela at its southern tip. The Koggala lagoon, a basin estuary, could be considered a coastal lake. The lagoon is situated about 130 km south of Colombo and separated from the Indian Ocean by a narrow sand bar during most of the year. The sand bar develops near Katoluwa, where the lagoon opens to the sea, 2 km south of the Koggala Township.





The present study analyzed some physiochemical parameters and phytoplankton composition of the water in selected study sites of the Lagoons.

In Batticaloa lagoon and Negombo lagoon, different areas having different pysico-chemical variations. In this study limited numbers of parameters were taken into the account and two high salinity areas (estuaries) and two moderate salinity areas have been taken into account to estimate phytoplankton fluctuation according to seasonal variations. Based on this study there is a possibility to prepare the document about phytoplankton fluctuation in freshwater areas and estuaries.

The objective of the present study was to determine;

1. the phytoplankton composition, species diversity & the density of different phytoplankton species of the lagoon in different seasons.
2. the role of physico – chemical properties on the occurrence of phytoplankton assemblage in the lagoon water.
3. the sequence of changes in their biomass with the nutrient enrichment of the lagoon due to releases from the catchments.
4. the condition of the lagoon water during blooms.
5. the possibility of using species diversity & density of phytoplankton in the lagoon and diversity indices for the prediction of water quality using phytoplankton as environmental indicators.

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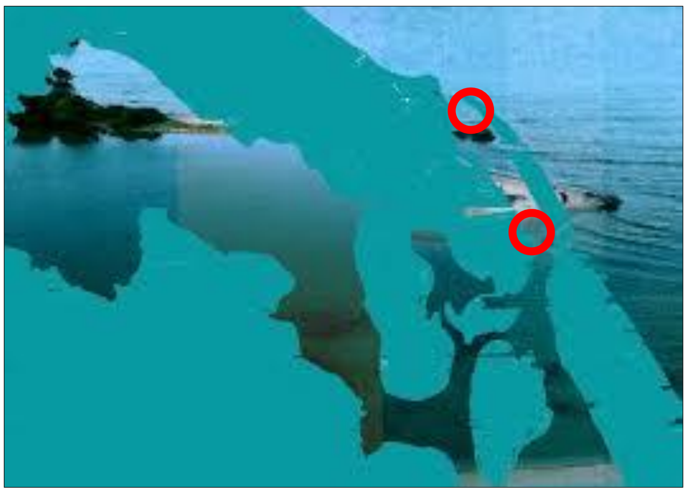
3. Methodology

3.1. Study area and sampling locations of Batticaloa lagoon and Negombo lagoon

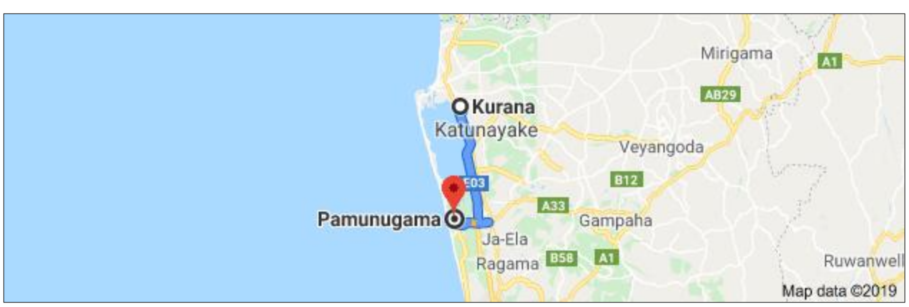
The study area Batticaloa lagoon is categorized into three basins, which are Northern basin, Southern basin and Intermediate basin. During 2020 investigation period, in **February** and **June (dry season)** and **October** and **November (rainy season)** water samples were collected. The sampling region Palameenmadu (A) is located at intermediate basin which is close sea and the sampling region kallady (B) is located at intermediate region which is 5.52 km away from the region Palameenmadu (A) and during rainy season sea water intrusion is possible. The water temperature, salinity, conductivity and pH were measured directly at the sampling locations.



Palameenmadu (A) & Kallady (B) in Batticaloa lagoon

Kurana area (A) & Pamunugama area (B) in Negombo lagoon

The study area Negombo lagoon is categorized into two basins, which are Northern basin and Southern basin. During 2020 investigation period, in **February** and **March (dry season)** and **October** and **November (rainy season)** water samples were collected. The sampling region Kurana (A) is located at Northern basin which is close sea and the sampling region Pamunugama (B) is located at Southern basin which is 19.3 km away from the region Kurana (A) and during rainy season sea water intrusion is possible. The water temperature, salinity, conductivity and pH were measured directly at the sampling locations.



Distance between Kurana to Pamunugama is 19.3 km

Water samples were collected at 10 m distance away from the shore by using a boat at the secchi disk level. So in dry season four samples from Batticaloa lagoon and four samples from

Negombo lagoon, then in wet season four samples from Batticaloa lagoon and four samples from Negombo lagoon, totally 16 water samples were collected in the year 2020 and analysed. The phytoplankton members were identified at genus level.

In this study, the Batticaloa lagoon and its catchment was considered as an interacting ecosystem. Any activity within the catchment may influence the quality of water in its inlets thus causing changes in the phytoplankton assemblage of the lagoon. In the study, the Negombo lagoon is characterised by high biodiversity in its flora and fauna. The mangrove community in the lagoon is the most diverse of all mangrove communities in the west coast of Sri Lanka. The zonation of plants and animals in the mangroves is not as spectacular as that in South East Asia, because of the low tidal fluctuation, but in the number of species of plants and animals in the lagoon, mangroves, seagrasses and mudflats. Muthurajawela also helps to mitigate floods, raise the water level in local wells and filter water before discharging into the lagoon. The Department of Wildlife Conservation has rightly recognised the conservative value and declared Muthurajawela as a wildlife-bird sanctuary and established the Muthurajawela Visitor Centre.

Muthurajawela wetland

These changes could cause changes in the phytoplankton biomass within the lagoon. Therefore specifically two sampling regions in each lagoon were selected to represent seasonal variation of phytoplankton in these two lagoons.

3.2. Collection of water samples, Sampling procedure and Estimation of phytoplankton at genus level

Water sampling was carried out during the period of dry season (February and June) and wet season (October and November) of the year 2020 and during the investigation period the following physico-chemical and biological parameters were estimated. The months January shows more or less same pattern of reading of wet season. The sampling locations were Palameenmadu and Kallady in Batticaloa lagoon and Kurana and Pamunugama in Negombo lagoon. At each sampling region secchi depths were determined using a black & white disc of 0.25 m in diameter, operated from the boat for comparative purposes. Then water samples were collected with the help of Ruttner sampler with a volume of 2.5 L operated from the boat. The following physio-chemical and biological parameters were estimated.

Salinity, Conductivity, pH, Water Temperature, Total phosphate, Nitrate, Chloride and Phytoplankton species diversity and density at genus level.

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3.3. Phytoplankton composition and enumeration

For phytoplankton studies water samples (2.5 L) collected with the Ruttner sampler were transferred to plastic bottles (2.5 L), the bottles, which contain water samples, were transferred to laboratory as quick as possible. The 100 ml of the water sample was taken from the plastic bottle and treated with Lugol's solution at the rate of 100:1 in order to fix and preserve the phytoplankton. The Lugol's solution was prepared by dissolving 10 g of pure iodine and 20 g of KI in 200 ml of distilled water to which 20 ml glacial acetic acid was added three days prior to sampling. The solution was kept in dark bottles. Iodine, which is usually prepared as Lugol's solution, offers the double advantage of making cells heavy enough to settle. Therefore, the preservation and counting of many flagellates was made possible. Therefore the most suitable phytoplankton preservative is Lugol's solution, which can be used for all forms including the naked flagellates. (Anon, 1992a)

3.4. Isolation of phytoplankton

From the preserved sample a syringe removed 90 ml of supernatant carefully. It was confirmed that the supernatant did not have any algal cells. The remaining concentrated 10 ml of the sample was centrifuged at 4000 r.p.m. For 15 minutes. After centrifuging 9 ml of supernatant was removed carefully by filler. It was confirmed that the supernatant do not have any algal cells. The final 1ml concentrated solution of 100 ml sample, was subjected to species composition and algal counts (Anon, 1992a).

Identification at genus level was done by using a key for "identification of freshwater algae common in water supplies and polluted waters" (Anon, 1992a). Identification at species level was done by the following method. At the beginning the distinguishing features of each species were carefully recorded. In this regard the following identification parameters were considered, which are presence or absence of plastids (prokaryotes or eukaryotes), unicell (motile or non-motile & shape of the cell), colony (motile or non-motile cells), filamentous (shape of cells, presence or absence of any frustule's projections).

3.5. Counting of phytoplankton:

(Anon, 1992a) Counting of phytoplankton was done by using a Haemocytometer through compound microscope (Olympus / Tokyo No: 615534). From the concentrated 1ml sample, sub samples were taken using a pipette and placed on the haemocytometer for identification and counting. Counting was done in triplicates for enumeration of phytoplankton density. Observation made through low (x40) and medium (x100) power. The volume of squares of haemocytometer was pre-calculated as follows.

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4. Result and Discussion

Physico-chemical parameters of Batticaloa Lagoon

4.1. Water Temperature

The water temperature in February dry season 30 ^{o}C and 29 ^{o}C were recorded at Palameenmadu (A) and Kallady (B) respectively. In June dry season 32 ^{o}C and 31 ^{o}C recorded at Palameenmadu (A) and Kallady (B) respectively and in October and November rainy season in both sampling locations 28 ^{o}C was recorded. The water temperature was obviously slightly reduced in rainy season.

4.2. Salinity

The salinity in February dry season 32 ppt and 29 ppt were recorded at Palameenmadu (A) and Kallady respectively and in October rainy season the salinity values were slightly reduced which were 30 ppt and 26 ppt at Palameenmadu (A) and Kallady (B) respectively. In June dry season 37 ppt and 31 ppt were recorded at Palameenmadu (A) and Kallady respectively and in November rainy season the salinity values were slightly reduced which are 32 ppt and 24 ppt at Palameenmadu (A) and Kallady (B) respectively. The salinity values were reduced in rainy season.

Salinity is one of the most important factor and it exerts various effects on the vitality of marine organisms (Abdo, 2005) and can be used as a good tool to evaluate lagoon status (AbdEllah and Hussein, 2009). Salinity inside the lagoon varied within a narrow interval value was closest to those found in the coastal water except during warmer periods when values were slightly higher (37‰).

4.3. Conductivity

The conductivity in February dry season 335 µS/cm and 300 µS/cm were recorded at Palameenmadu (A) and Kallady (B) respectively and in October rainy season the conductivity values were reduced which are 329 µS/cm and 275 µS/cm at Palameenmadu (A) and Kallady (B) respectively. In June dry season 400 µS/cm and 335 µS/cm were recorded at Palameenmadu (A) and Kallady (B) respectively and in November rainy season the conductivity values were reduced which are 300 µS/cm and 270 µS/cm at Palameenmadu (A) and Kallady (B) respectively. The conductivity values were highly reduced in rainy season.

4.4. pH

The pH in February dry season 8 and 7 were recorded at Palameenmadu (A) and Kallady (B) respectively and in October rainy season the pH values were slightly reduced which are 7.2 and 7 at Palameenmadu (A) and Kallady (B) respectively. In June dry season 9 and 8 were recorded at Palameenmadu (A) and Kallady (B) respectively and in November rainy season the pH values were slightly reduced which are 7 at both locations Palameenmadu (A) and Kallady (B).

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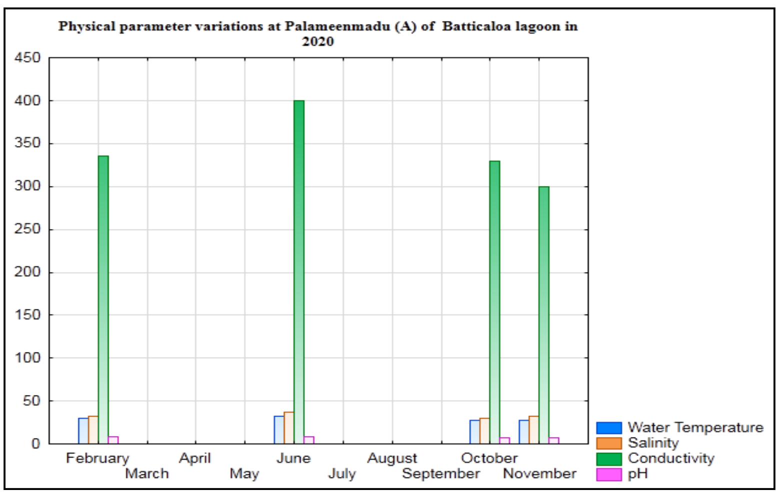
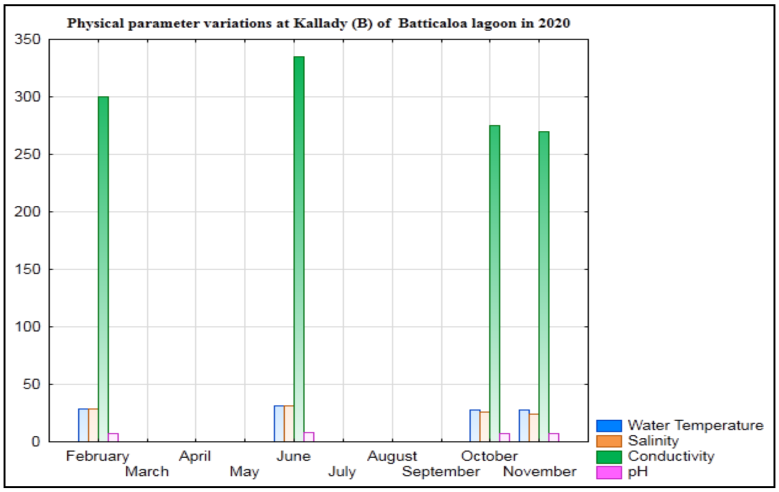
Physical parameters in **February (dry season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B) in Batticaloa lagoon**				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Palameenma. (A)	**30**	**32**	**335**	**8**
Kallady (B)	**29**	**29**	**300**	**7**
Physical parameters in **June (dry season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Palameenma. (A)	**32**	**37**	**400**	**9**
Kallady (B)	**31**	**31**	**335**	**8**
Physical parameters in **October (rainy season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Palameenma. (A)	**28**	**30**	**329**	**7.2**
Kallady (B)	**28**	**26**	**275**	**7**
Physical parameters in **November (rainy season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Palameenma. (A)	**28**	**32**	**300**	**7**
Kallady (B)	**28**	**24**	**270**	**7**





4.5. Total Phosphate

The total phosphate in February dry season at Palameenmadu (A) and Kallady (B) were 0.09 and 0.06 respectively. In June dry season at Palameenmadu (A) and Kallady (B) were 0.02 and 0.01 respectively. **It was noted that the total phosphate level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 0.04 mg/l and 0.03 mg/l at Palameenmadu (A) and Kallady (B) respectively. In November rainy season there was a slight increase in both sampling locations which was 0.04 mg/l at both sampling locations Palameenmadu (A) and Kallady (B).

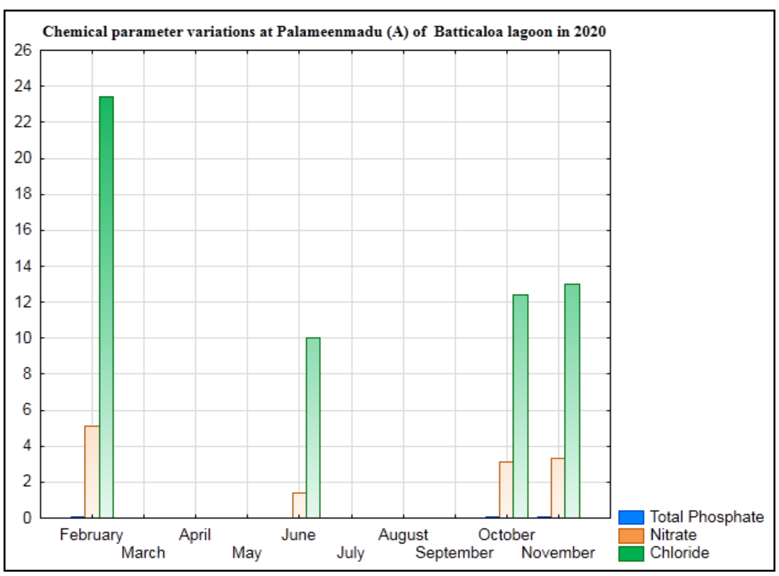
4.6. Nitrate

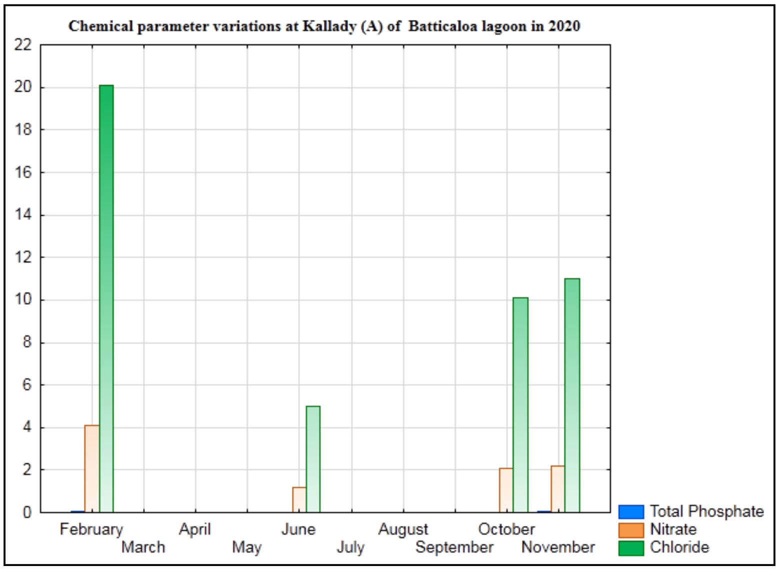
The nitrate level in February dry season at Palameenmadu (A) and Kallady (B) were 5.1 mg/l and 4.1 mg/l respectively. In June dry season at Palameenmadu (A) and Kallady (B) were 1.4 mg/l and 1.2 mg/l respectively. **It was noted that the nitrate level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 3.1 mg/l and 2.1 mg/l at Palameenmadu (A) and Kallady (B) respectively. In November rainy season there was a slight increase in both sampling locations which were 3.3 mg/l and 2.2 mg/l at the sampling locations Palameenmadu (A) and Kallady (B) respectively.

4.7. Chloride

The chloride level in February dry season at Palameenmadu (A) and Kallady (B) were 23.4 mg/l and 20.1 mg/l respectively. In June dry season at Palameenmadu (A) and Kallady (B) were 10 mg/l and 5 mg/l respectively. **It was noted that the chloride level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 12.4 mg/l and 10.1 mg/l at Palameenmadu (A) and Kallady (B) respectively. In November rainy season there was a slight increase in both sampling locations which were 13 mg/l and 11 mg/l at the sampling locations Palameenmadu (A) and Kallady (B) respectively.

Chemical parameters in **February (dry season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B) in Batticaloa lagoon**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Palameenma. (A)	**0.09**	**5.1**	**23.4**
Kallady (B)	**0.06**	**4.1**	**20.1**
Chemical parameters in **June (dry season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Palameenma. (A)	**0.02**	**1.4**	**10**
Kallady (B)	**0.01**	**1.2**	**5**
Chemical parameters in **October (rainy season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Palameenma. (A)	**0.04**	**3.1**	**12.4**
Kallady (B)	**0.03**	**2.1**	**10.1**
Chemical parameters in **November (rainy season) 2020** at the sampling stations **Palameenmadu (A) and Kallady (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Palameenma. (A)	**0.04**	**3.3**	**13**
Kallady (B)	**0.04**	**2.2**	**11**





Physico-chemical parameters of Negombo Lagoon

4.8. Water Temperature

The water temperature in February dry season 31.21 ^{o}C and 31.23 ^{o}C were recorded at Kurana (A) and Pamunugama (B) respectively and in October rainy season the water temperature values were reduced which are 30.21 ^{o}C and 30.23 ^{o}C at Kurana (A) and Pamunugama (B) respectively. In June dry season 32.44 ^{o}C and 32.32 ^{o}C were recorded at Kurana (A) and Pamunugama (B) respectively and in November rainy season the water temperature values were reduced which are 30 ^{o}C at both sampling locations Kurana (A) and Pamunugama (B).

4.9. Salinity

The salinity in February dry season 34 ppt and 33 ppt were recorded at Kurana (A) and Pamunugama (B) respectively and in October rainy season the salinity values were slightly reduced which were 33.2 ppt and 33 ppt at Kurana (A) and Pamunugama (B) respectively. In June dry season 34 ppt and 35 ppt were recorded at Kurana (A) and Pamunugama (B) respectively and in November rainy season the salinity values were slightly reduced which are 32.34 ppt and 32.21 ppt at Kurana (A) and Pamunugama (B) respectively. The salinity values were reduced in rainy season.

4.10. Conductivity

The conductivity in February dry season 366 µS/cm and 356 µS/cm were recorded at Kurana (A) and Pamunugama (B) respectively and in October rainy season the conductivity values were reduced which are 335 µS/cm and 320 µS/cm at Kurana (A) and Pamunugama (B) respectively. In June dry season 376 µS/cm and 360 µS/cm were recorded at Kurana (A) and Pamunugama (B) respectively and in November rainy season the conductivity values were reduced which are 324 µS/cm and 320 µS/cm at Kurana (A) and Pamunugama (B) respectively. The conductivity values were highly reduced in rainy season.

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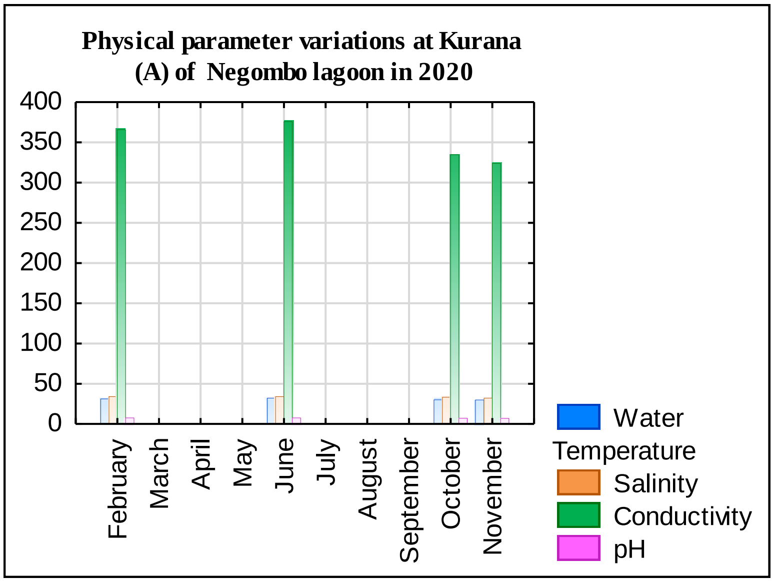
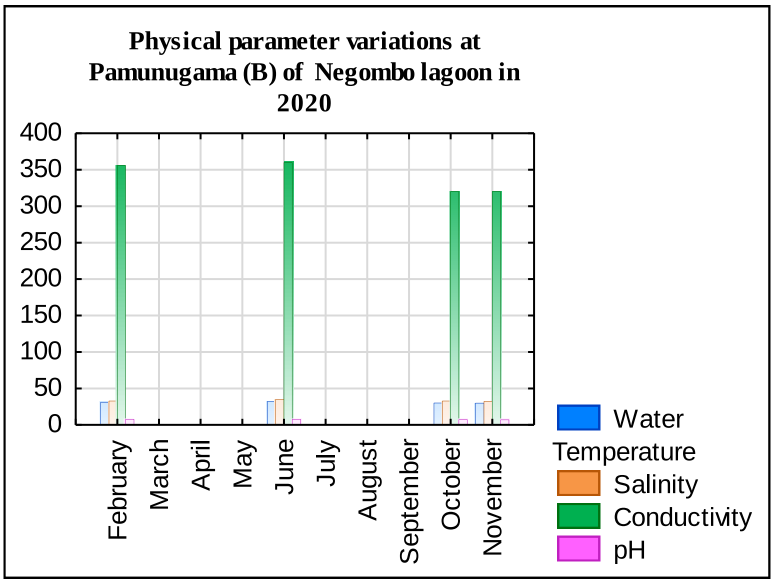
4.11. pH

The pH in February dry season 7.68 and 7.75 were recorded at Kurana (A) and Pamunugama (B) respectively and in October rainy season the pH values were reduced which are 7.21 and 7.32 at Kurana (A) and Pamunugama (B) respectively. In June dry season 7.77 and 7.72 were recorded at Kurana (A) and Pamunugama (B) respectively and in November rainy season the pH values were reduced which are 7.11 and 7.12 at Kurana (A) and Pamunugama (B) respectively. The pH values were reduced in rainy season.

Physical parameters in **February (dry season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B) in Negombo lagoon**				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Karuna (A)	**31.21**	**34**	**366**	**7.68**
Pamanugama (B)	**31.23**	**33**	**356**	**7.75**
Physical parameters in **June (dry season) 2020** at the sampling stations **Kurana (A) and Pamunugama** (B)				
Sampling station	**Water Temp. ºC**	**Salinity ppt**	**Conductivity µS/cm**	**pH**
Karuna (A)	**32.44**	**34**	**376**	**7.77**
Pamanugama (B)	**32.32**	**35**	**360**	**7.72**
Physical parameters in **October (rainy season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B)**				
Sampling station	**Water Temp. ºC**	**Salinity %**	**Conductivity µS/cm**	**pH**
Karuna (A)	**30.21**	**33.2**	**335**	**7.21**
Pamanugama (B)	**30.23**	**33**	**320**	**7.32**
Physical parameters in **November (rainy season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B)**				
Sampling station	**Water Temp. ºC**	**Salinity %**	**Conductivity µS/cm**	**pH**
Karuna (A)	**30**	**32.34**	**324**	**7.11**
Pamanugama (B)	**30**	**32.21**	**320**	**7.12**





4.12. Total Phosphate

The total phosphate in February dry season at Kurana (A) and Pamunugama (B) were 0.1 and 0.12 respectively. In June dry season at Kurana (A) and Pamunugama (B) were 0.01 and 0.02 respectively. **It was noted that the total phosphate level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 0.03 mg/l and 0.04 mg/l at Kurana (A) and Pamunugama (B) respectively. In November rainy season there was a slight increase in both sampling locations which were 0.042 mg/l and 0.049 at Kurana (A) and Pamunugama (B) sampling locations respectively.

4.13. Nitrate

The nitrate level in February dry season at Kurana (A) and Pamunugama (B) were 4.1 mg/l and 3.1 mg/l respectively. In June dry season at Kurana (A) and Pamunugama (B) were 1.2 mg/l and 1.1 mg/l respectively. **It was noted that the nitrate level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 2.9 mg/l and 2.7 mg/l at Kurana (A) and Pamunugama (B) respectively. In November rainy season there was a slight decrease in sampling locations Kurana (A) and Pamunugama (B) were 2.6 mg/l and 2.4 mg/l respectively.

4.14. Chloride

The chloride level in February dry season at Kurana (A) and Pamunugama (B) were 27.4 mg/l and 22.2 mg/l respectively. In June dry season at Kurana (A) and Pamunugama (B) were 12 mg/l and 7 mg/l respectively. **It was noted that the chloride level was highly reduced in June. This may be the reason of lockdown period about COVID-19 (March, April & May, 2020).** In October rainy season there was a slight increase in both sampling locations which were 13.4 mg/l and 12.1 mg/l at Kurana (A) and Pamunugama (B) respectively. In November rainy season there was a slight decrease in both sampling locations which were 12.2 mg/l and 11.6 mg/l at the sampling locations Kurana (A) and Pamunugama (B) respectively.

Chemical parameters in **February (dry season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B) in Negombo lagoon**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Karuna (A)	**0.1**	**4.1**	**27.4**
Pamanugama (B)	**0.12**	**3.1**	**22.2**
Chemical parameters in **June (dry season) 2020** at the sampling stations **Kurana and Pamunugama (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Karuna (A)	**0.01**	**1.2**	**12**
Pamanugama (B)	**0.02**	**1.1**	**7**
Chemical parameters in **October (rainy season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Karuna (A)	**0.03**	**2.9**	**13.4**
Pamanugama (B)	**0.04**	**2.7**	**12.1**
Chemical parameters in **November (rainy season) 2020** at the sampling stations **Kurana (A) and Pamunugama (B)**			
Sampling station	**Total Phosphate mg/L**	**Nitrate mg/L**	**Chloride mg/L**
Karuna (A)	**0.042**	**2.6**	**12.2**
Pamanugama (B)	**0.049**	**2.4**	**11.6**

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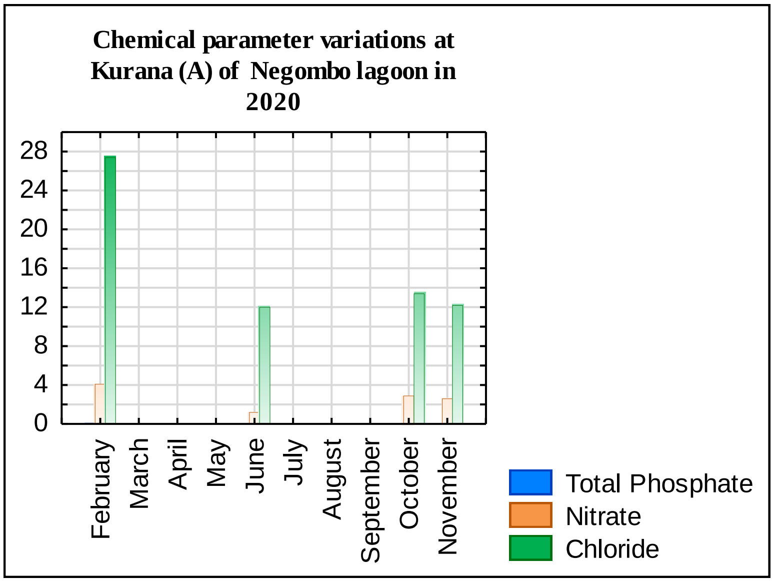

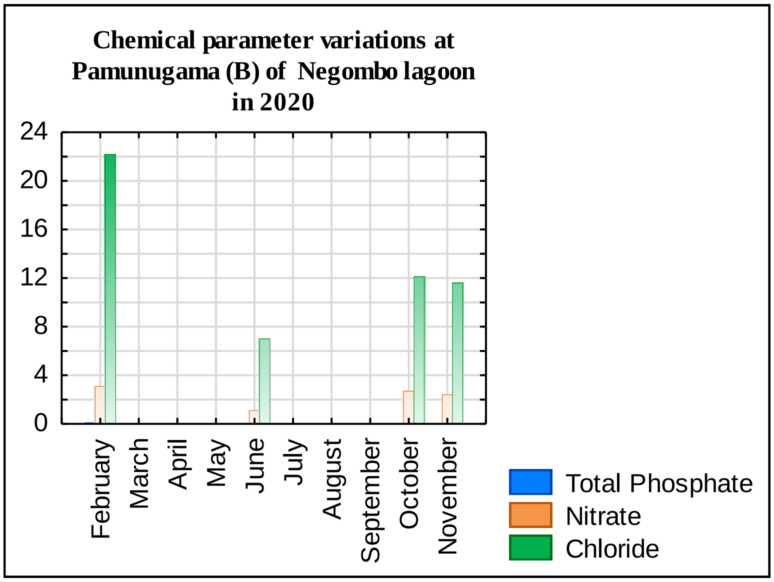

According to (Ladipo et al., 2011) all the locations reflected little influence of seasons with slightly higher values during the dry season than the wet season.

4.15. Phytoplankton distribution and composition was affected by the change in seasons & Curfew and Lockdown due to COVID-19

Phytoplankton are tiny plant-like organisms that, with zooplankton, are constituents of plankton that drift on the surface of the lagoons. Phytoplankton use photosynthesis to fix carbon and obtain energy, and are vital to the marine food web and to the planetary ecosystem as a whole.

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Phytoplankton are algae, and require sunlight for photosynthesis. They also require specific nutrients such as nitrates, phosphates and silicates that are derived from the upwelling of deep nutrient-rich waters. Both these factors are affected by the change in seasons.

The so-called "spring bloom" of phytoplankton is well documented. This typically occurs in early spring to late spring / early summer. It is seen particularly in temperate North Atlantic and sub-polar regions, regions that are subject to considerable seasonal changes in sunlight. The increase in temperature is also a factor in increased phytoplankton growth.

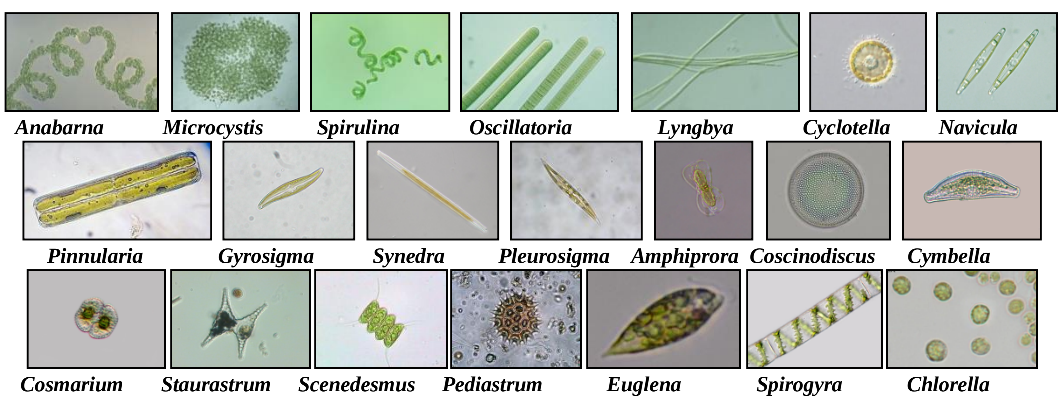
In June 2020 (after March, April & May, 2020) the assemblage of phytoplankton clearly indicating as bioindicators the quality of water which means the toxin producing cyanobacterial members were highly reduced and diatoms and desmids were increased it indicates the pollution level is highly reduced and the quality of water improved.

4.15.1. Genus identified at Palameenmadu (A) in February, June, October and November 2020

February 2020

At the sampling location Palameenmadu (A) during dry season (February, 2020) 21 phytoplankton members were identified which are;

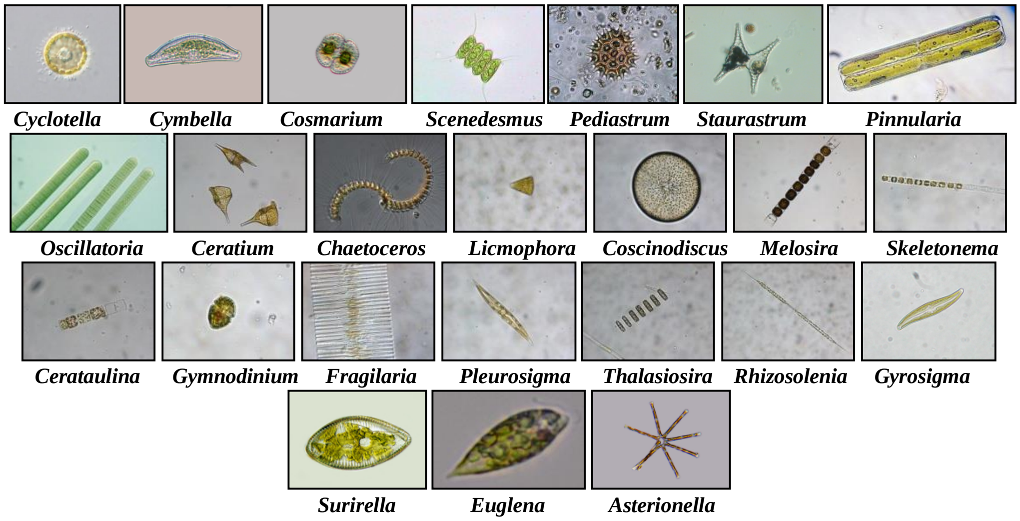
Anabarna, Microcystis, Spirulina, Oscillatoria, Lyngbya, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Pleurosigma, Amphiprora, Coscinodiscus, Cymbella, Cosmarium, Staurastrum, Scenedesmus, Pediastrum, Euglena, Spirogyra, and Chlorella.



June 2020

At the sampling location Palameenmadu (A) during dry season (June, 2020) 24 phytoplankton members were identified which are;

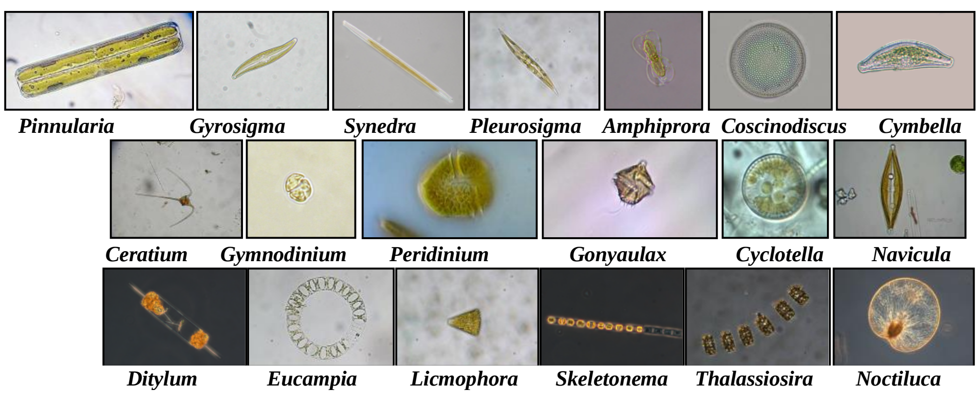
Cyclotella, Cymbella, Cosmarium, Scenedesmus, Pediastrum, Staurastrum, Pinnularia, Oscillatoria , Ceratium, Chaetoceros, Licmophora, Coscinodiscus , Melosira , Skeletonema,Erataulina, Gymnodinium, Fragilaria , Pleurosigma Thalasiosira, Rhizosolenia, Gyrosigma, Surirella, Euglena, Asterionella



October 2020

At the sampling location Palameenmadu (A) during wet season (October, 2020) 19 phytoplankton members were identified which are;

Pinnularia, Gyrosigma, Synedra, Pleurosigma, Amphiprora, Coscinodiscus, Cymbella, Ceratium, Gymnodinium, Peridinium, Gonyaulax, Cyclotella, Navicula, Ditylum, Eucampia, Licmophora, Skeletonema, Thalassiosira, Noctiluca



November 2020

At the sampling location Palameenmadu (A) during wet season (November, 2020) 18 phytoplankton members were identified which are;

Anabarna, Microcystis, Oscillatoria, Lyngbya, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Pleurosigma, Amphiprora, Coscinodiscus, Cymbella, Cosmarium, Scenedesmus, Pediastrum, Euglena, and Spirogyra.

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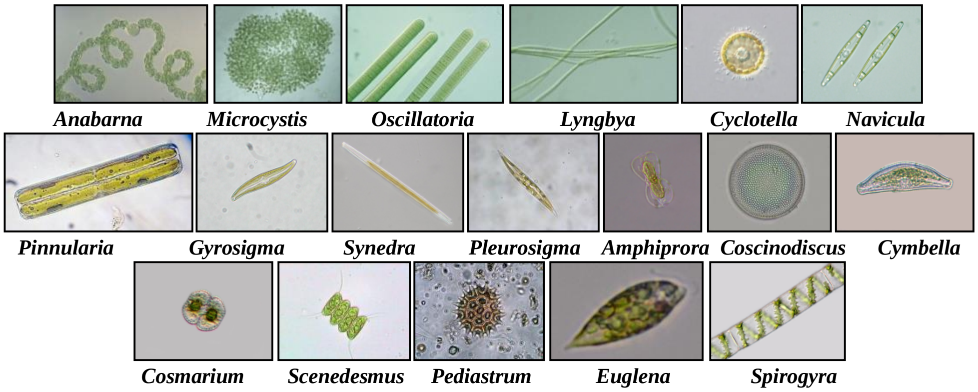
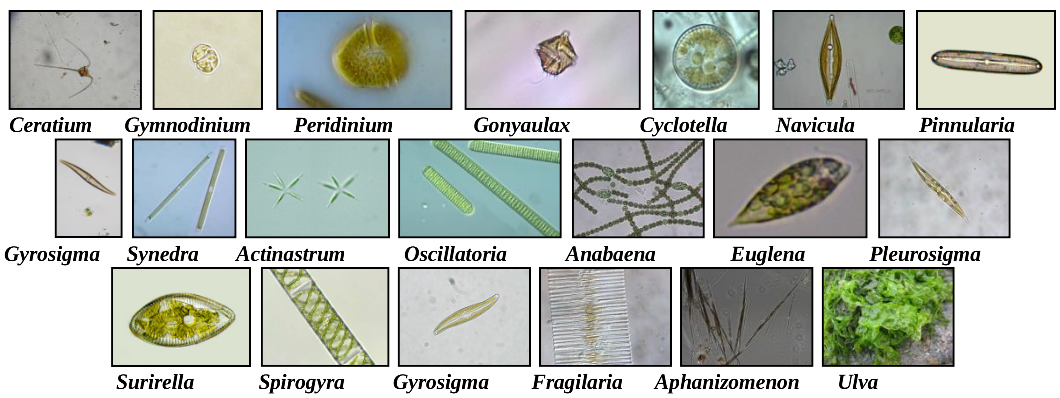


4.15.2. Genus identified at Kallady (B) in February, June, October and November 2020

February 2020

At the sampling location Kallady (B) during dry season (February, 2020) 20 phytoplankton members were identified which are;

Ceratium, Gymnodinium, Peridinium, Gonyaulax, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Actinastrum, Oscillatoria, Anabaena, Euglena, Pleurosigma , Surirella , Spirogyra, Gyrosigma, Fragilaria, Aphanizomenon, and *Ulva*.



June 2020

At the sampling location Kallady (B) during dry season (June, 2020) 26 phytoplankton members were identified which are; Additionally two members were identified which were; *Aphanizomenon, Navicula*

Cyclotella, Cymbella, Cosmarium, Scenedesmus, Pediastrum, Staurastrum, Pinnularia, Oscillatoria , Ceratium, Chaetoceros, Licmophora, Coscinodiscus , Melosira , Skeletonema, Cerataulina, Gymnodinium, Fragilaria , Pleurosigma Thalasiosira, Rhizosolenia, Gyrosigma, Aphanizomenon, Navicula, Surirella, Euglena, Asterionella

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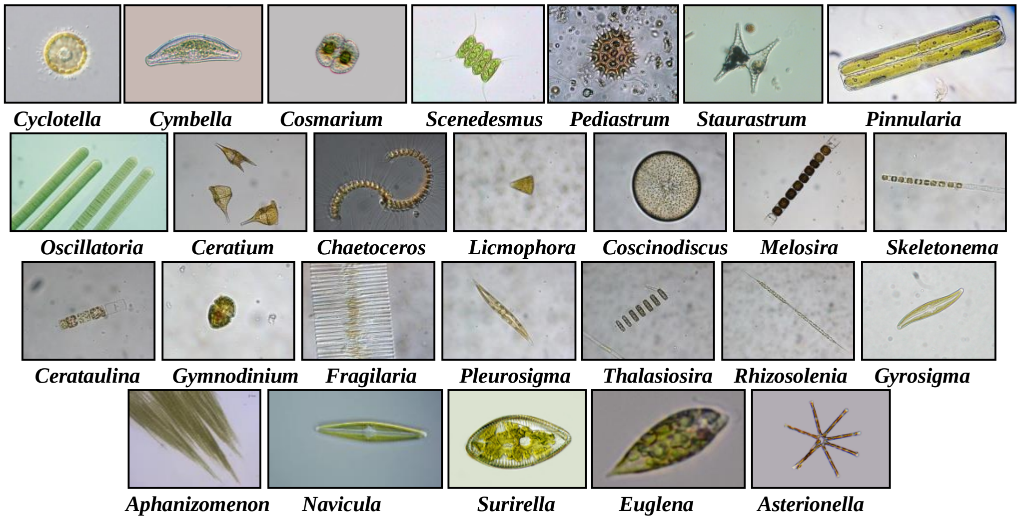
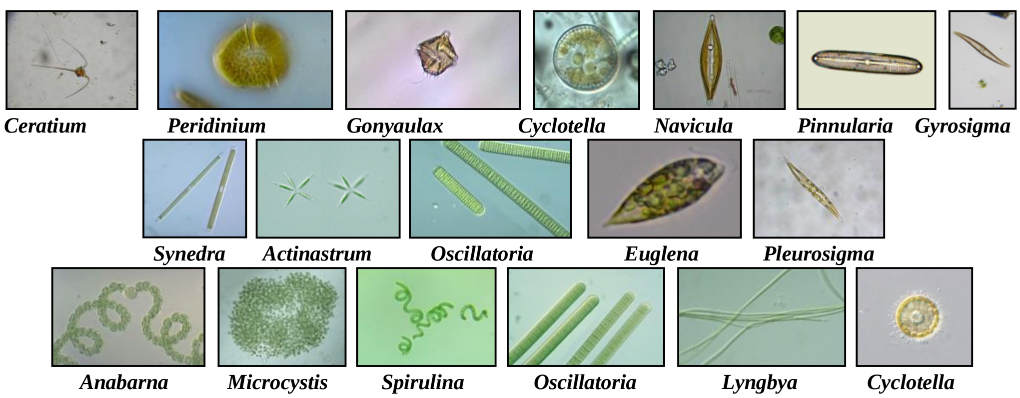


October 2020

At the sampling location Kallady (B) during wet season (October, 2020) 18 phytoplankton members were identified which are;

Ceratium, Peridinium, Gonyaulax, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Actinastrum, Oscillatoria, Euglena, Pleurosigma, Anabarna, Microcystis, Oscillatoria, Lyngbya, Cyclotella



November 2020

At the sampling location Kallady (B) during wet season (November, 2020) 17 phytoplankton members were identified which are;

Ceratium, Peridinium, Gonyaulax, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Actinastrum, Oscillatoria, Anabaena, Euglena, Pleurosigma, Surirella , Spirogyra, Fragilaria, and *Ulva*.

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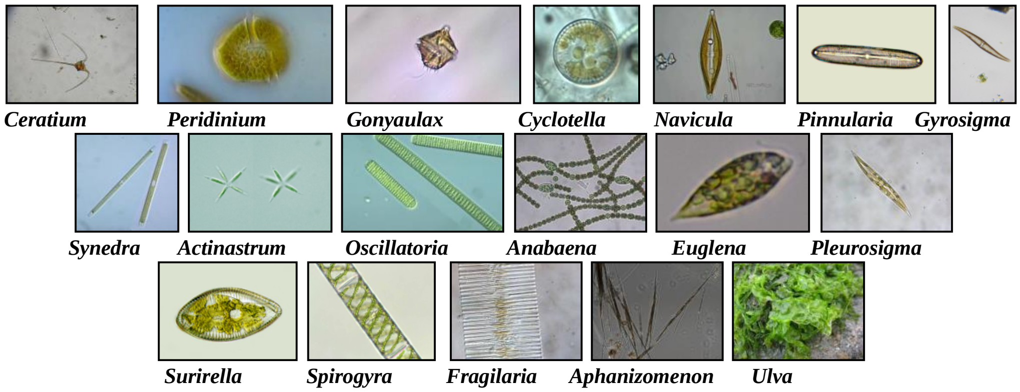


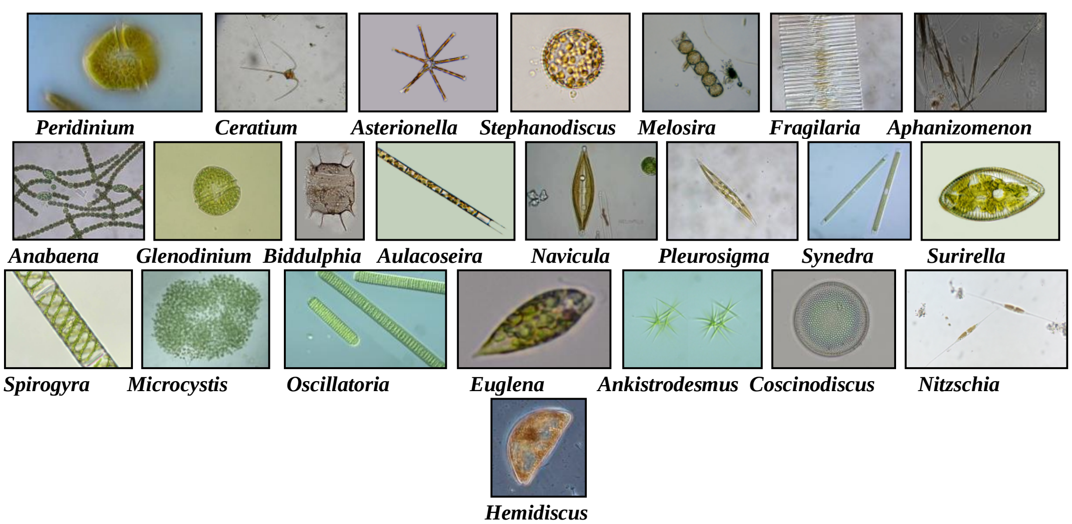
4.15.3. Genus identified at Kurana (A) in February, June, October and November 2020

February 2020

At the sampling location Kurana (A) during dry season (February, 2020) 23 phytoplankton members were identified which are;

Peridinium , Ceratium, Asterionella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Aulacoseira, Navicula, Pleurosigma, Synedra , Surirella , Spirogyra, Microcystis, Oscillatoria, Euglena, Ankistrodesmus , Coscinodiscus, Nitzschia, Hemidiscus.

The most dominant among the pollution indicators were ***Pleurosigma, Synedra*** , and ***Eugllena.***



June 2020

At the sampling location Kurana (A) during dry season (June, 2020) 24 phytoplankton members were identified which are;

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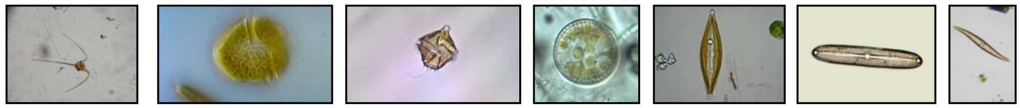
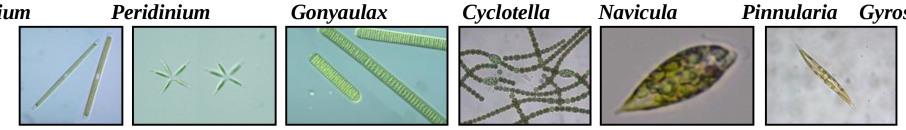
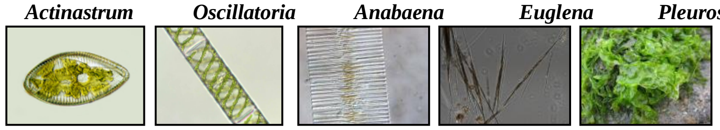
Ceratium, Peridinium, Gonyaulax, Cyclotella, Navicula, Pinnularia, Gyrosigma, Synedra, Actinastrum, Oscillatoria, Anabaena, Euglena, Pleurosigma, Surirella , Spirogyra, Fragilaria, Ulva, Cerataulina , Gymnodinium ,Pleurosigma, Thalasiosira Rhizosolenia , and Gyrosigma



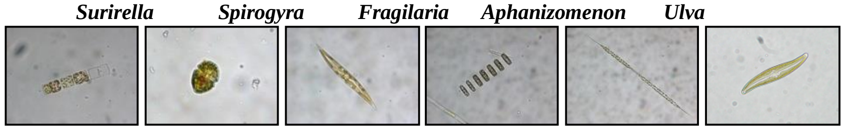
Ceratium ***Peridinium*** ***Gonyaulax*** ***Cyclotella*** ***Navicula*** ***Pinnularia*** ***Gyrosigma***



Synedra ***Actinastrum*** ***Oscillatoria*** ***Anabaena*** ***Euglena*** ***Pleurosigma***



Surirella ***Spirogyra*** ***Fragilaria*** ***Aphanizomenon*** ***Ulva***

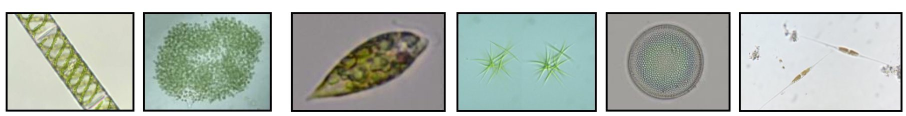


Cerataulina ***Gymnodinium*** ***Pleurosigma*** ***Thalasiosira*** ***Rhizosolenia*** ***Gyrosigma***

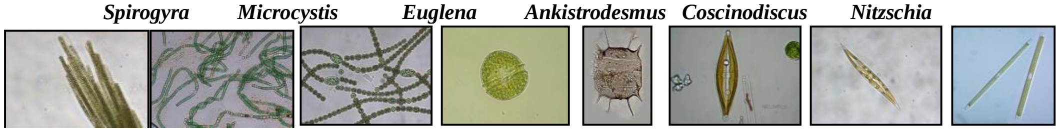
October 2020

At the sampling location Kurana (A) during wet season (October, 2020) 17 phytoplankton members were identified which are;

Spirogyra, Microcystis, Euglena, Ankistrodesmus, Coscinodiscus, Nitzschia, Aphanizomenon, Nodularia, Anabaena, Glenodinium, Biddulphia, Navicula Pleurosigma, Synedra, Surirella, Staurastrum, Spirulina



Spirogyra ***Microcystis*** ***Euglena*** ***Ankistrodesmus*** ***Coscinodiscus*** ***Nitzschia***



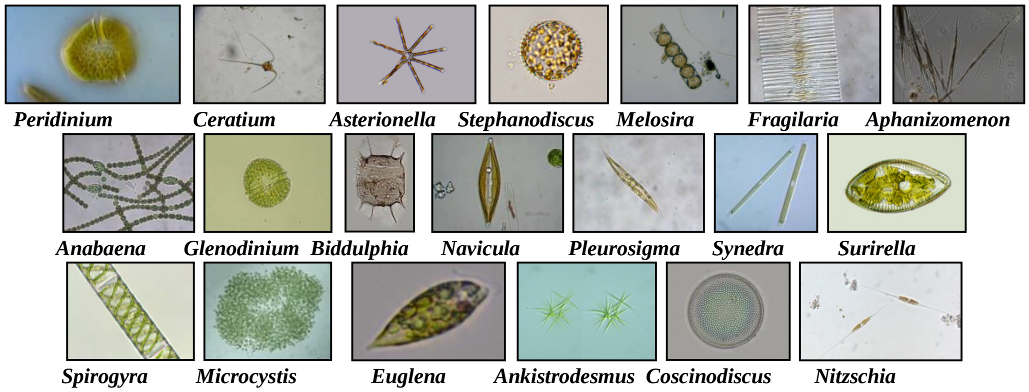
Aphanizomenon ***Nodularia*** ***Anabaena*** ***Glenodinium*** ***Biddulphia*** ***Navicula*** ***Pleurosigma*** ***Synedra***

Surirella ***Staurastrum*** ***Spirulina***

November 2020

At the sampling location Kurana (A) during wet season (November, 2020) 20 phytoplankton members were identified which are;

Peridinium , Ceratium, Asterionella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Navicula, Pleurosigma , Euglena, Synedra , Surirella , Spirogyra, Ankistrodesmus, Coscinodiscus, Nitzschia. The following phytoplankton members were missing *Pleurosigma, and Synedra.*

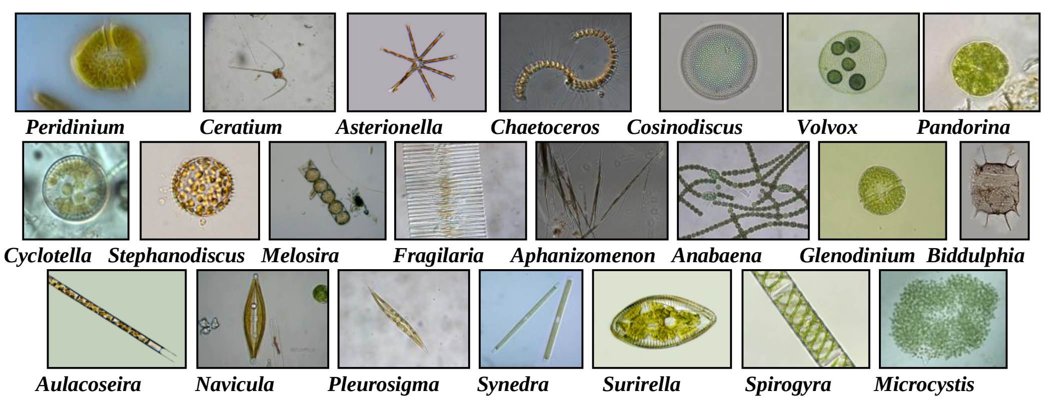


4.15.4. Genus identified at Pamunugama (B) in February, June, October and November 2020

February 2020

At the sampling location Pamunugama (B) during dry season (February, 2020) 26 phytoplankton members were identified which are;

Peridinium, Ceratium, Asterionella, Chaetoceros, Cosinodiscus, Volvox, Pandorina, Cyclotella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Aulacoseira, Navicula , Pleurosigma , Synedra , Surirella , Spirogyra, Microcystis, Oscillatoria, Anabaena, Euglena, Ankistrodesmus, Nitzschia , Hemidiscus, Chlamydomonas .



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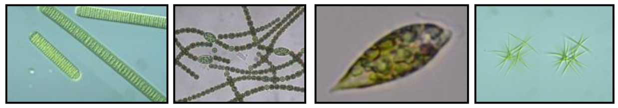
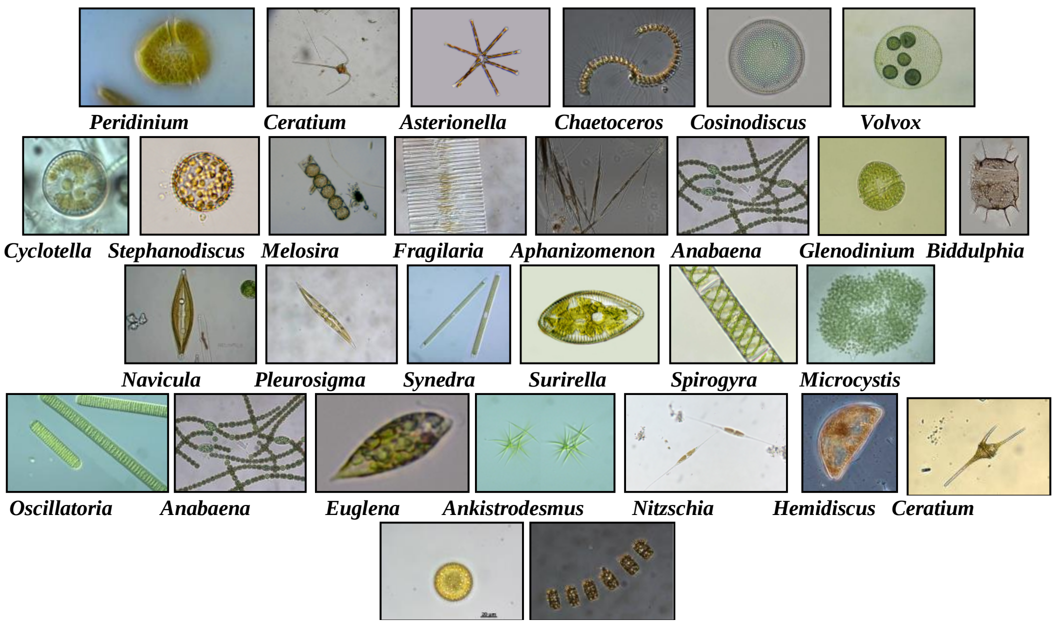


Oscillatoria ***Anabaena*** ***Euglena*** ***Ankistrodesmus***

June 2020

At the sampling location Pamunugama (B) during dry season (June, 2020) 29 phytoplankton members were identified which are;

Peridinium , Ceratium, Asterionella, Chaetoceros, Cosinodiscus, Volvox,Cyclotella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Navicula , Pleurosigma , Synedra , Surirella , Spirogyra, Microcystis, Oscillatoria, Anabaena, Euglena, Ankistrodesmus, Coscinodiscus, Nitzschia, Hemidiscus, Ceratium, Stephanodiscus, Thalassiosira.

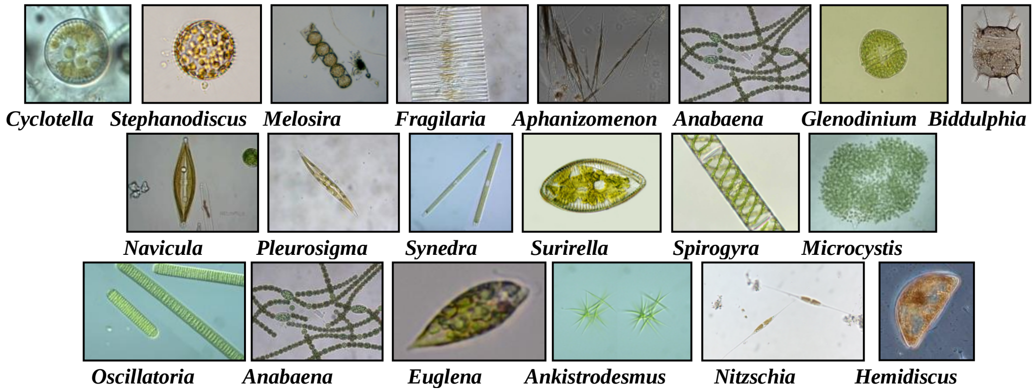


Peridinium ***Ceratium*** ***Asterionella*** ***Chaetoceros*** ***Cosinodiscus*** ***Volvox***
Cyclotella ***Stephanodiscus*** ***Melosira*** ***Fragilaria*** ***Aphanizomenon*** ***Anabaena*** ***Glenodinium*** ***Biddulphia***
Navicula ***Pleurosigma*** ***Synedra*** ***Surirella*** ***Spirogyra*** ***Microcystis***
Oscillatoria ***Anabaena*** ***Euglena*** ***Ankistrodesmus*** ***Nitzschia*** ***Hemidiscus*** ***Ceratium***
Stephanodiscus ***Thalassiosira***

October 2020

At the sampling location Pamunugama (B) during wet season (October, 2020) 20 phytoplankton members were identified which are;

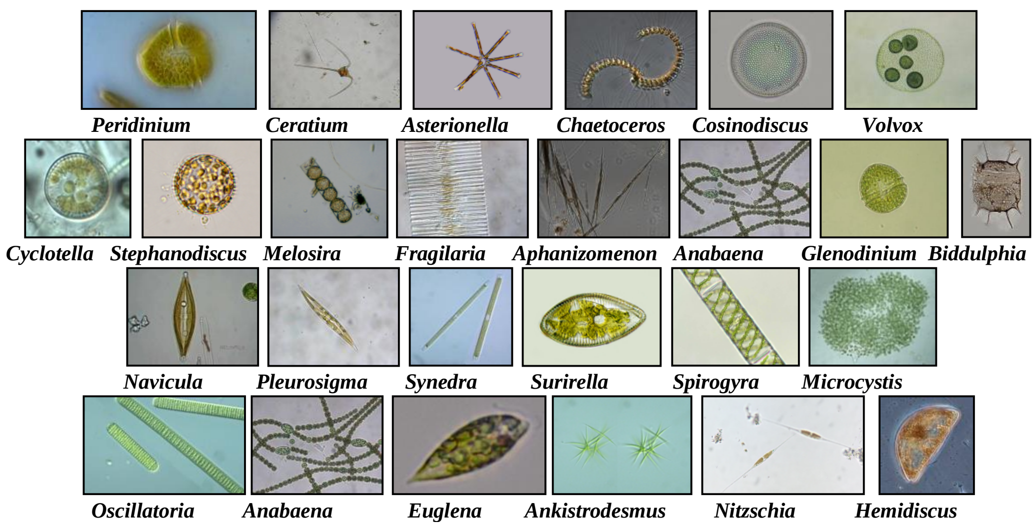
Cyclotella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Navicula , Pleurosigma , Synedra , Surirella , Spirogyra, Microcystis, Oscillatoria, Anabaena, Euglena, Ankistrodesmus, Coscinodiscus, Nitzschia, Hemidiscus.



November 2020

At the sampling location Pamunugama (B) during wet season (November, 2020) 26 phytoplankton members were identified which are;

Peridinium , *Ceratium, Asterionella, Chaetoceros, Cosinodiscus, Volvox, Cyclotella, Stephanodiscus, Melosira, Fragilaria, Aphanizomenon, Anabaena, Glenodinium, Biddulphia, Navicula* , *Pleurosigma* , *Synedra* , *Surirella* , *Spirogyra, Microcystis, Oscillatoria, Anabaena, Euglena, Ankistrodesmus, Coscinodiscus, Nitzschia, Hemidiscus.*



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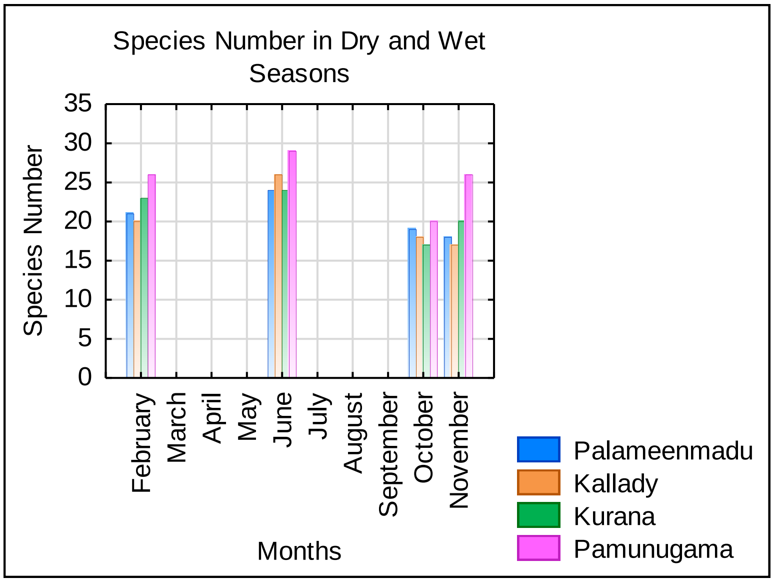

Higher number of species of the ***Chlorophyta*** and ***Cyanophyta*** in the dry and rainy season, respectively is indicative of the water quality in the two seasons. (Klemer *et al*., 1996; Zimba *et al*., 1999, 2006)

5. Conclusion

After the Curfew and lockdown period i.e. March, April & May, 2020 the pollution levels especially total phosphate, Nitrate and Chloride were highly reduced in the month June, 2020 (dry season) and the species diversity was increased and the species density was reduced at the all four sampling locations (Palameenmadu, Kallady – Batticaloa Lagoon, & Karuna, Pamanugama – Negombo Lagoon) in June, 2020. Some Desmids also identified during this period and it indicates the quality of water become considerably clean and pollution free. Very low number of toxin producing cyanobacterial members *Microcystis* and *Anabaena* were identified and freshwater phytoplankton members *Aphanizomenon* and *Staurastrum* were also identified. At the bar mouth areas some dinoflagellates were identified.

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