The Water Chemistry, Phytoplankton Biomass (Chlorophyll *a*), Episammic and Periphytic Algae of the Apese Lagoon, Lagos.

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ABSTRACT: The Apẹsẹ lagoon, hitherto is unreported in literature. The water chemistry, phytoplankton biomass (chlorophyll *a*), episammic and periphytic algae of the Apẹsẹ lagoon and the proximate sea in Lagos were investigated. Samples were collected in Feb., 2009 as part of a series of studies on the ecology of the Apẹsẹ lagoon. Preliminary results from the study revealed a classical tropical marine lagoon. Records show alkaline pH, high brackish conditions, salinity, conductivity and total dissolved solids comparative to a few lagoons in the region. Furthermore high dissolved oxygen and low biological oxygen demand were also associated with the lagoon. Comparatively, the marine conditions recorded for the Apẹsẹ lagoon were clearly below records from the simultaneously investigated proximate sea. A total of 34 algal species from 26 genera were recorded. Diatoms (25 species) and blue-green algae (8 species) were the more important groups occurring with regard to diversity and density of occurrence. In terms of composition and abundance, the periphytic community was richer (23 taxa) than the episammic assemblage (15 taxa). Chlorophyll *a* levels were higher in the lagoon than the sea. However, levels were lower with regard to reports for the region. The chlorophyll *a*, water chemistry and microalgal components reflected a tropical unpolluted marine aquatic environment. Relationship to other lagoons in the region is also highlighted within. There is need for further hydrological and ecological studies of the Apẹsẹ lagoon. [Report and Opinion. 2009;1(5):31-40]. (ISSN: 1553-9873).

Key words: water chemistry, phytoplankton biomass, episammic, epiphytic, Apẹsẹ lagoon, south-western Nigeria.

1. INTRODUCTION

Lagoons are prominent hydrological features along the West African Coast (Onyema *et al*., 2008). They are ecologically and economically important aquatic ecosystems in South-western Nigeria. Additionally, they are important for food especially fish, in water transportation, energy generation, exploitation and exploration of some mineral resources including sand (Kirk and Lauder, 2000; Onyema *et al*., 2007; Chukwu and Nwankwo, 2004; Onyema and Nwankwo, 2009).

The fundamental importance of algal components in trophic relationships in the aquatic environments as autotrophs and their bio-indicator value have been assessed and reported in literature over the years (Palmer, 1969; Valandingham, 1989, Dakshini and Soni, 1982). Similarly, in South-western Nigeria there are reports on some of the lagoons and adjoining creeks to this regard (Onyema and Nwankwo, 2006; Onyema, 2007b; Nwankwo and Akinsoji, 1989, 1992; Nwankwo, 2004b).

Microlgal components satisfy conditions to qualify as suitable indicators in that they are simple, capable of quantifying changes in water quality, applicable over large geographic areas and can also furnish data on background conditions and natural variability (Onyema, 2007b). More so micro algal components respond rapidly to perturbations and are suitable bio-indicators of water condition which are beyond the tolerance of many other biota used for monitoring (Nwankwo and Akinsoji, 1992; Nwankwo, 2004; Onyema, 2007). Some related investigations on attached algal components include Nwankwo *et al*., (1994), Onyema (2007a) and Onyema and Nwankwo (2006).

This is an attempt to report preliminary findings on the Apẹsẹ lagoon which has previously remained unreported. This account hence gives first time records for physico-chemical characteristics and aspects of the micro algal component of the lagoon.

2. MATERIALS AND METHODS

Probable Mode of Formation of the Apese Lagoon from the Former Kuramo Lagoon.

Before now, there were 9 reported lagoons in the south-western Nigeria (Onyema, 2008). The discovery of an additional lagoon (Apẹsẹ lagoon) in the region was made possible using the Google earth satellite mapping software. This was before *in situ* confirmation and pilot studies were carried out for validation. It is possible that the Apẹsẹ lagoon was ‘created’ out of the previously existing Kuramo lagoon (Hill and Webb, 1958; Sandison, 1966; Sandison and Hill, 1966). In previous reports, the Kuramo lagoon was much longer and extended further to the east of its current coverage. Coastal sediment build up may have filled up the median portion of the former Kuramo lagoon giving rise to a dichotomy i.e. Kuramo lagoon to the West and Apẹsẹ lagoon to the east. It is additionally possible that the exacerbated erosion effect from the construction of the west and east moles (1901 to 1930) had ebbed and possible accretion/build up of sediment followed at and around the east sea shore of the Kuramo lagoon. This probably elicited the fill up of part of the lagoons length. Consequently, giving rise to two independent and distinct lagoons.

Description of the Study Lagoon

The Apẹsẹ lagoon is the smallest of the ten lagoons in South -western Nigeria (Fig 1). It lies between Latitude 6^{o} 25¨20.8N, Longitude 3^{o} 27”15.5E and Latitude 6^{o} 25” 20.29N, Longitude 3^{o} 27¨57.1E (Onyema, 2009). The region is located in Victoria Island, Lagos state. The lagoon is lanceolate in shape and approximately 32,000m^2 in coverage area, 1.3km long and 0.16km across its widest extreme. It is located directly eastward of the Kuramo lagoon about 1.24km. The lagoon is about one third of the coverage of Kuramo lagoon. The lagoon is also separated from the proximate sea by less than 100m of sand bar (beach).

The area is exposed to the wet (May - November) and dry season (December to April) with the wet season having a bimodal distribution. Reports from the locals suggest that in the wet season the water volume of the lagoon increases in volume and the depth increases. Parts of the littoral zone are submerged. The vegetation type of the Apẹsẹ lagoon shore is a strand of scrubby vegetation similar to that described by Akinsoji *et al*., (2002) for the shore of the Light house beach. Some species occurring at the Apẹsẹ lagoon include *Ipomoea pes-caprae*, *Philoxerus* sp., *Paspalum vaginatum, Schizachryrium pulchellum* and *Remirea maritima*. Artisanal fishing and the collection of molluscan shells as souvenir for tourist in the lagoon and the sea is the main occupation of the few inhabitants of the immediate area.

It is worthy of note that a good number of the exactitudes for the Apẹsẹ lagoon were obtained by using the Google earth satellite mapping software.

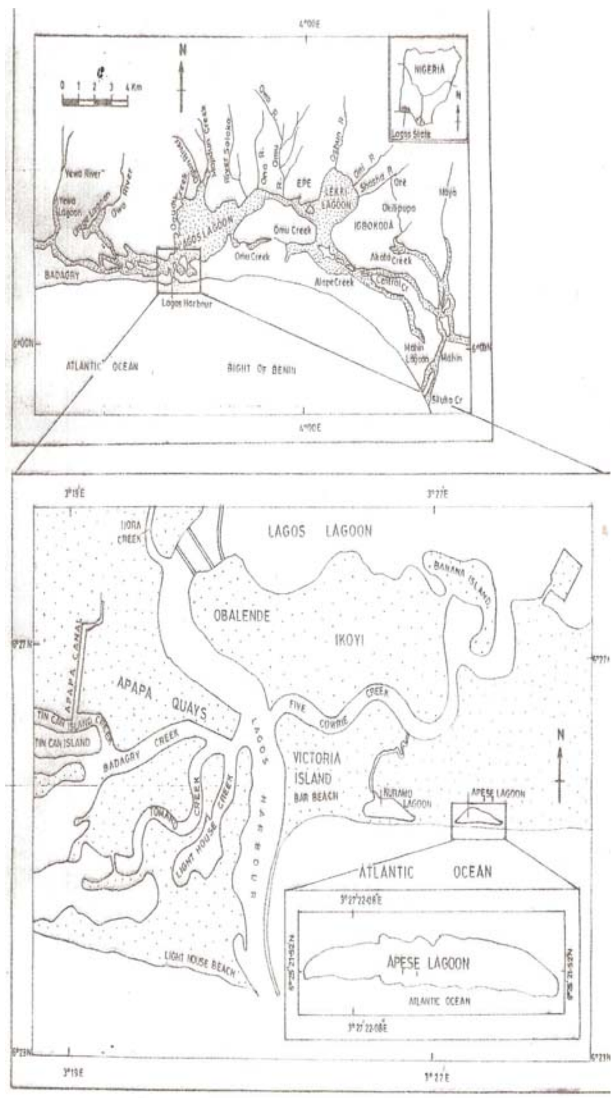

Fig 1: South-western Nigeria lagoons and a map trail to Apẹsẹ lagoon (bottom left).

Water sample collection:

Surface water samples were collected from the lagoon at stations A (Latitude 6° 25' 20.32" N, Longitude 3° 27"27.61E) and B (Latitude 6° 27"19.20N, Longitude 3° 27" 44.51E) and at the nearby sea (Atlantic ocean) (Station C - Latitude 6° 25"16.11N, Longitude 3° 27"35.12E) about 80m away (across the beach berm). The two samples for the lagoon were collected just a few centimeters below the water surface for physical and chemical characteristics analysis using 500ml plastic containers with screw caps at noon on the 2nd of February, 2009 at the Apẹsẹ lagoon. At the ocean front (Station C), water sample was collected by moving inward about 3m from the mid splash point zone. The plastic containers for both the lagoon and ocean samples were then labeled appropriately and transported to the laboratory and subjected to immediate physical and chemical characteristics analysis.

Collection of episammic and periphytic algal samples.

Sediment (episammic) samples were collected from exposed intertidal zone at low tide and at stations A and B. Sediment samples that were suspected to contain algal components as a result of their greenish colouration were collected. In collection, methods described by Hendey (1964) and Onyema (2007a) were employed. Consequently a 5cm^2 strip of the exposed inter – tidal zone at low tide was scrapped with a spatula into two appropriately labeled petri dishes (Onyema, 2007a). The samples were then slightly wetted with 4% unbuffered formalin for preservation and labeled before onward transportation to the laboratory.

In the collection of periphytic algal samples, plastic container found with recognizable growth of algae (i.e greenish / slimy appearance) at the lagoon shores at stations A and B were recovered and dabbed with formalin till all the greenish growth had been soaked. The recovered plastic containers were then put in a black polyethylene bag that was labeled aptly to reflect collection details for both stations. The samples were then preserved with 4% unbuffered formalin.

Analysis of sediment (episammic) and periphytic algal samples.

In the laboratory, the sediment was mixed with distilled water, slackened thoroughly and washed to facilitate the dislodgement and extraction of the algae as described by Hendey (1964). The supernatant thereof was then concentrated to 20ml prior to microscopic analysis as described by Onyema and Ojo (2008). Light microscope investigations on composition and abundance were conducted within 4hours after which samples were persevered with formalin to enable further investigation and confirmation. The periphytic samples on plastic containers were first of all scrapped with a knife into an empty glass beaker and then further brushed to remove any remaining attached algal components. 20ml of distilled water was then added with formalin for preservation. The constituted sample was then subjected to microscopic analysis as described by Onyema and Ojo (2008) after strong perturbation to allow for proper homogenization. Identification was made using relevant texts (Hendey 1958, 1964; Wimpenny, 1966; Patrick and Reimer, 1966, 1975; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; Bettrons and Castrejon, 1999; Lange-Bertalot, 2001; Witkowski *et al*., 2000; Siver, 2003; Rosowski, 2003).

3. RESULTS.

Temperature, water chemistry characteristics and chlorophyll *a* concentration.

Table 1 presents the status of the physico-chemical parameters at the two stations (St. A and St. B) within the Apẹsẹ lagoon in Feb., 2009, their mean, standard error, variance, standard deviation and that of the proximate sea (St. C). Air temperature values were between 31.8 and 32.0 ^{0}C with a mean value of 31.90 ^{0}C for the lagoon whereas the sea recorded 31.9 ^{0}C. Water temperature values were between 28.8 and 28.9^{0}C with a mean value of 28.85 ^{0}C for the lagoon while the sea recorded 27.5 ^{0}C. pH at 26^0 values were also between 8.27 and 8.26 for the lagoon whereas the sea recorded 8.52. Furthermore, conductivity values were between 30610 and 30650 µS/cm respectfully and an average of 30630.00µS/cm at stations A and B, while station C recorded 52150 µS/cm. For Total Suspended Solids, values were between 30 and 31 mg/L for the lagoon whereas the proximate sea recorded 28 mg/L. Total Dissolved solids values recorded a mean of 18023.50 mg/L for the lagoon whereas the sea recorded 31605 mg/L.

Salinity estimates for stations A and B were between 17.1 and 17.3‰ with an average of 17.20‰ , whereas the sea recorded 30.8‰. Acidity on the other hand were between 4.5 and 4.48 mg/L with a mean value of 4.49mg/L for the lagoon whereas station C recorded 4.4 mg/L. Similarly, Alkalinity values were between 280.0 and 281.5 mg/L at stations A and B, whereas station C recorded 350.0 mg/L. Total Hardness were between 21000.0 and 21100 mg/L with a mean value of 21050.00 mg/L for the lagoon whereas the sea recorded 33750 mg/L.

For cations, Calcium recorded lower values than Magnesium and was 1200 mg/L at both stations A and B and the sea recorded 2400 mg/L and Magnesium was between 4306.2 and 4310 mg/L with a mean value of 4308.10mg/L for the lagoon whereas the sea recorded 6638.8 mg/L. For heavy metals, Zinc values were between 0.015 and 0.016 mg/L the lagoon, whereas the ocean front recorded 0.016mg/L. Iron levels was 0.15 for both stations A and B and the sea recorded 0.16 mg/L. Copper values was 0.007 mg/L for both stations A and B, whereas the sea recorded 0.006 mg/L. Chlorides values were between 7623.4 and 7631.3 mg/L with a mean value of 7627.35 mg/L for the lagoon whereas the sea recorded 8022.1mg/L.

For the nutrients, Nitrate values were between 4.1 and 4.2 mg/L with a mean value of 4.15 mg/L at stations A and B, whereas station C recorded 5.1 mg/L. Sulphate values were between 3620.1 and 3625.7 mg/L with a mean value of 3622.90 mg/L for the lagoon whereas the sea recorded 3633.2 mg/L. Phosphate values were between 0.05 and 0.06mg/L with a mean value of 0.055 mg/L at stations A and B, whereas station C recorded 0.06 mg/L. Silica values on the other hand were between 3.6 and 3.7 mg/L with an average value of 3.65 mg/L for the lagoon whereas the sea recorded 3.4 mg/L.

Biological Oxygen Demand at both stations in the lagoon and the sea recorded 2 mg/L. Chemical Oxygen Demand estimates were also between 10 and 11mg/L with a mean value of 10.5 mg/L for the lagoon whereas the sea recorded 12 mg/L. Dissolved Oxygen values were between 4.80 and 4.95mg/L for the lagoon whereas the sea recorded 5.0 mg/L.

Phytoplankton biomass represented by chlorophyll *a* (µg/L) on the other hand was between 6.00 and 7.50 µg/L with a mean value of 6.75 µg/L at stations A and B, whereas the sea recorded 5 µg/L.

Episammic and periphytic algae.

Table 2 present the taxonomy and distribution of microalgal components recorded on the sediment and plastics of the Apẹsẹ lagoon in February, 2009. The episammic and periphytic algae are reported. In Table 2, the episammic / sediment algae are represented by Sediment algae St. A and Sediment algae St. B, whereas the periphytic algae are reported under Periphytic algae St. A and Periphytic algae St. B. A total of 34 microalgal components from 26 genera were identified and recorded.

Episammic algae

The total number of species recorded in station A were 12 while the total number in station B was 13. *Lynbgya limnetica* Lemm. was the more important algal species in terms of number of occurrence (Station B). Stations B recorded some species which were not present at station A (*Actinoptychus splendens* Ehrenberg, *Arachnoidiscus* sp, *Cyclotella* sp., *Paralia sulcata* (diatoms), *Microcystis aureginosa* (blue-green algae). Similarly Station A recorded *Cocconeis placentula* (Ehrenberg), *Gyrosigma scalproides*, *Pleurosigma angulatum*, *Pleurosigma elongatum* (diatoms), *Merismopedia gluca* (blue-green) and *Euglena* sp. (euglenoid) not recorded in Station B.

Periphytic algae

The total number of species recorded in station A were 22 while the total number in station B was 21. *Amphora ovalis*, *Cocconeis placentula* and *Licmophora lyngbei* were more important in terms of number. Stations A and B comprised similar periphytic assemblages. However, *Melosira nummuloides* and *Paralia sulcata* were only recorded in station A while *Pleurosigma angulatum*, *Pleurosigma elongatum*, *Thalasiothrix fraunfeldii* (diatoms) and *Lynbgya martensiana* (blue-green algae) were recorded in higher numbers in station A than in station B. Similarly, in station B *Amphiphora alata*, *Cocconeis discuslus*, *Diploneis crabro* and *Surirella ovata* recoded higher numbers than in station A.

4. DISCUSSION

It's worthy of note that the data from this investigation is preliminary and represent findings at the time of collection (Feb., 2009) which may not necessarily be a true reflection of the seasonality to which the lagoon is more truly exposed to. Air and water temperatures were within tropical limits for the lagoon and sea. Air temperature was higher than water temperature for the lagoon. According to Onyema (2008) the air is known to heat up faster (from insolation) than the water during the day (in the region) as the sun rises. Consequently, at night also the air usually cools faster than the water.

For all the parameters measured, there were modicum differences between the two sites in the lagoon. However, comparative to the sea, more quantitative disparities were recorded. For instance with regard to salinity, the Apẹsẹ lagoon recorded high brackish water situation. Estimates for pH, conductivity, total dissolved solids, alkalinity, total hardness, calcium, magnesium, iron, chlorides, nitrate, sulphate, phosphate, chemical oxygen demand and dissolved oxygen were higher in seawater than the lagoon water. Conversely, estimates for water temperature, total suspended solids, acidity, zinc, copper, silica and chlorophyll *a* were higher in the lagoon than the sea. pH was alkaline for both the lagoon and sea. Other workers have reported alkaline pH in some lagoons in the area (Onyema *et al*., 2003, 2008; Nwankwo *et al.*, 2008) and linked it to the buffering effect of sea water and associated high levels of dissolved bi-carbonates therein. This condition from the sea may be the strong determinant of the pH of the lagoon. Other lagoons in the region have recorded less alkaline and sometimes acidic conditions (Nwankwo, 1998a,b; Onyema and Nwankwo, 2009; Onyema and Emmanuel, 2009; Nwankwo *et al*., 2008). The direct and strong relationships between salinity, chlorides, conductivity, total hardness and total dissolved solids have been reported by a number of ecologists for the region (Nwankwo 1993, Onyema, 2008; Onyema and Nwankwo, 2009). Similarly, the cations, calcium and magnesium are also known to follow like trend (Onyema and Nwankwo, 2009).

With regard to salinity, cations and associated aforementioned parameters, levels for the sea were higher than estimates for the lagoon. Typically, values were generally about half of estimated levels for the sea at the time. Additionally, values for these parameters for the Apese lagoon were higher than for other lagoons in the region (Nwankwo *et al*., 2003, 2008, Onyema, 2008, Nwankwo, 1998b). Heavy metal levels (copper, iron and zinc) were low for the study. Similarly biological and chemical oxygen demand levels were low. Presently, this may be the lowest for any of the other nine lagoons and manifold creeks in the region. This may additionally point to an unpolluted status for the lagoon. According to Hynes (1960) BOD_5 values higher than $8mgl^{-1}$ points to severe pollution. The creeks and lagoons of south-western Nigeria, apart from their more ecological and economic significance, serve as sink for the disposal of an increasing array of waste types (Onyema, 2007b). Succinct examples of lagoons as sinks include the Lagos, kuramo and Ologe lagoons (Nwankwo, 2004b).

It is important to note that dissolved oxygen values were also comparatively high. The sea estimates for dissolved oxygen were higher though, probably a reflection of the perturbations and agitations of breaking waves at the beach. Further to this, comparative to lagoons in the region (Nwankwo, 1993, 1998a, Onyema and Nwankwo 2009, Onyema *et al*., 2007, Nwankwo *et al*., 2008) higher dissolved oxygen were recorded for this study. Reported nutrient levels (Nitrate, Phosphate, Sulphate and Silica) were within ranges that have been reported for other lagoons. Nutrient levels in the other lagoon are keyed to rainfall influx which introduces a lot of nutrient rich components (allouchthonus materials) from land based sources. According to Onyema *et al*., (2003) the diluting and enriching effects of floodwaters, inflow of seawater and the existence of environmental gradients govern the distribution of Lagos lagoon biota. This area (Onyema, 2007a) is also known to maintain high brackish to sea conditions throughout the year. Available chlorophyll *a* concentrations were lower when comparated to reports from the region. Whereas Onyema and Nwankwo (2009) reported a range of 4.2 to 55 µg/L for a two year study of the Iyagbe lagoon, Onyema and Ojo (2008) reported a range of 8.3 to 22.1 µg/L for two stations in the Agboyi creek adjoining the Lagos lagoon over a six month period. According to a chlorophyll *a* scale documented by Suzuki *et al*., (2002) for trophic levels, the Apese lagoon falls into the Oligotrophic category with regard to primary production levels.

It is possible to deduce that from the trend of comparative data elicited from this preliminary survey, that the sea conditions are largely impacting the ecological characteristics of the Apese lagoon. However there is need for a larger pool of consistent and continuous data to further substantiate this position or otherwise.

Comparatively, the periphytic assemblage was richer (in terms of diversity and abundance) than the episammic community. The algae *Lynbgya limnetica* Lemm was notable in terms of number and was present at both sites. Its important to note that many species reported for this study and community are similar to that reported by Onyema (2007a) for a mudflat (algae) at Tarkwa-bay. This similarity may be keyed to the proximity of the two points (Apese lagoon and bay) to the sea and like sediment characteristics. Pennate diatiom were clearly more diverse (19 species) than any other group. According to Round (1953) and Nwankwo and Akinsoji (1989) the possession of a raphe in diatoms is an asset effective in maneuvering through sediment and hence enhances survival in such habitats. The centric diatoms recorded a total of 6 species. Whereas the periphytic algae recorded a total of 22 species in station A and 21 species in station B, the episammic algae on the other hand recorded 12 species in station A and 13 species in station B. Hence, the plastics were better substrates in terms of diversity and abundance of associated species algal materials.

In general marine conditions were clearly evident in the Apẹsẹ lagoon especially pertaining to its water chemistry characteristics and microalgal components. Species such as *Actinoptychus splendens*, *Melosira moniliformis, Melosira nummuloides, Paralia sulcata, Achnanthes longipes*, *Amphiphora alata, Bacillaria paxillifer*, *Diploneis crabro, Gyrosigma scalproides, Pleurosigma angulatum, Licmophora lyngbei, Licmophora* sp. *Thalasiothrix fraunfeldii, Thalasionema longissima, Merismopedia gluca* are known to reflect alkaline pH and brackish water situations in the region (Nwankwo and Gaya, 1996; Nwankwo and Akinsoji, 1992; Onyema *et al*., 2003, 2007, 2008; Onyema, 2008). The algal diagnosis of the Apese lagoon points to an unpolluted marine lagoon with distinct oligotrophic characteristics. There is hence need for its conservation, because of its unique state and type comparative to lagoons in the region.

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Table 1: Status of Physical and Chemical Parameters of the Apese lagoon at Two Stations (Stations A and B) and the adjacent ocean (Station C) (Feb., 2009).

	PARAMETERS	ST. A	ST. B	Mean	Stand. dev	Variance	Stand. error	ST. C
1.	Air Temperature(^{0}C)	31.8	32.0	31.90	0.141	0.02	0.1	31.9
2.	Water Temperature (^{0}C)	28.9	28.8	28.85	0.071	0.005	0.05	27.5
3	pH at 26^0	8.27	8.26	8.27	0.007	0.00	0.005	8.52
4	Conductivity (µS/cm)	30610	30650	30630.00	28.284	800	20	52150
5.	Total Suspended Solids (mg/L)	30	31	30.50	0.707	0.5	0.5	28
6.	Total Dissolved solids (mg/L)	18020	18027	18023.50	4.949	24.5	3.5	31605
7.	Salinity (‰)	17.1	17.3	17.20	0.141	0.02	0.1	30.8

8.	Acidity (mg/L)	4.5	4.48	4.49	0.014	0.0002	0.01	4.4
9.	Alkalinity (mg/L)	280.0	281.5	280.75	1.061	1.125	0.75	350.0
10.	Total Hardness (mg/L)	21000.0	21100	21050.00	70.711	5000	50	33750
11.	Calcium (mg/L)	1200	1200	1200.00	0.00	0.00	0.00	2400
12.	Magnesium (mg/L)	4306.2	4310	4308.10	2.687	7.22	1.9	6638.8
13.	Zinc (mg/L)	0.016	0.015	0.02	0.00	0.00	0.00	0.016
14.	Iron (mg/L)	0.15	0.015	0.08	0.092	0.008	0.065	0.16
15.	Copper (mg/L)	0.007	0.007	0.01	0.00	0.00	0.00	0.006
16.	Chlorides (mg/L)	7623.4	7631.3	7627.35	5.586	31.205	3.95	8022.1
17.	Nitrate (mg/L)	4.2	4.1	4.15	0.070	0.005	0.05	5.1
18.	Sulphate (mg/L)	3620.1	3625.7	3622.90	3.959	15.68	2.8	3633.2
19.	Phosphate (mg/L)	0.05	0.06	0.055	0.007	0.00	0.005	0.06
20.	Silica (mg/L)	3.6	3.7	3.65	0.071	0.005	0.05	3.4
21.	Biological Oxygen Demand(mg/L)	2	2	2	0.00	0.00	0.00	2
22.	Chemical Oxygen Demand (mg/L)	10	11	10.5	0.707	0.5	0.5	12
23.	Dissolved Oxygen (mg/L)	4.80	4.95	4.875	0.106	0.011	0.075	5.0
24.	Chlorophyll *a* (μg/L)	6.00	7.50	6.75	1.060	1.125	0.75	5

Table 2: Taxonomy and distribution of episammic and periphytic algae at stations A and B in the Apẹsẹ lagoon.

Algal Taxa	Sediment algae St. A	Sediment algae St. B	Periphytic algae St. A	Periphytic algae St. B
DIVISION – BACILLARIOPHYTA				
CLASS - BACILLARIOPHYCEAE				
ORDER I – CENTRALES				
Actinoptychus splendens Ehrenberg	-	*	-	-
Melosira moniliformis Agardh	-	-	*	**
Melosira nummuloides Agardh	-	-	*	-
Arachnoidiscus sp	-	*	-	-
Cyclotella sp.	-	*	-	-
Paralia sulcata Ehrenberg	-	*	*	-
ORDER II – PENNALES				
Achnanthes longipes Agardh	-	-	*	*
Amphiphora alata Eherenberg	-	-	*	**
Amphora ovalis Kutzing	-	-	**	**
Bacillaria paxillifer (O.F. Muller) Hendey	*	*	-	-
Cocconeis discuslus (Schum) Cleve	-	-	*	**
Cocconeis placentula (Ehrenberg)	*	-	**	**
Cymbella affinis Kutzing	*	*	*	*
Diploneis crabro Eherenberg	-	-	*	**
Diploneis sp.	-	*	-	-
Gyrosigma scalproides (Rabh) Cleve	*	-	-	-
Pleurosigma angulatum (Quekett) Wm Smith	*	-	**	*
Pleurosigma elongatum Wm Smith	*	-	**	*
Licmophora lyngbei (Kutzing) Grunow	-	-	**	**
Licmophora sp.	*	*	-	-
Surirella ovata Kutzing	-	-	*	**
Synedra crystallina (Ag) Kutzing	-	-	*	*
Synedra sp.	-	-	*	*
Thalasiothrix fraunfeldii Cleve & Grunow	-	-	**	*
Thalasionema longissima Cleve & Grunow	-	-	*	*
DIVISION – CYANOPHYTA				

CLASS – CYANOPHYCEAE				
ORDER I – CHROOCOCCALES				
Chroococcus turgidus (Kutz.) Lemm	*	*	-	-
Merismopedia gluca (Ehr.) Nageli	*	-	-	-
Microcystis aureginosa Kutzing		*	*	*
Gleocapsa sp.	*	*	*	*
ORDER II – HORMOGONALES				
Lynbgya limnetica Lemm	-	***	*	*
Lynbgya martensiana Meneghini	-	-	**	*
Oscillatoria sp I.	*	*	-	-
Oscillatoria sp II.	-	-	*	*
DIVISION – EUGLENOPOHYTA				
CLASS – EUGLENOPHYCEAE				
ORDER – EUGLENALES				
Euglena sp.	*	-	-	-
Species diversity (S)	12	13	22	21

Where * represents 1 – 10 cells / colony / Individuals; ** represents 11 – 100 cells / colony / Individuals and *** represents 101 – 4500 cells / colony / Individuals.

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