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# Diversity of Diatom (Bacillariophyta) Flora from the Coastal Waters of Pakistan: A Review on Ecology and Taxonomy

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**Abstract**

Studies on diversity of diatom community including their seasonality and taxonomy have been carried out during the period of May 2002 to July 2003, July, 2007 and November, 2008. This paper focused on the ecological aspect which is always manifestly important as well as taxonomy and both are strongly interrelated. The studied area is heavily influenced by the Asian monsoon system results the production of diatom blooms which were observed in the month of September 2002 and February 2003. Strong negative relationship -0.218 and -0.054 observed between diatom abundance and chlorophyll a at both stations suggesting other factors like picoplanktons are contributing in chlorophyll a concentrations. Statistical analysis showed overall lower species diversity from 0.1 to 3.6. It suggests that organic loads decreased the abundance and diversity of diatom communities in the region. Taxonomy and seasonal abundance of potentially toxic bloom forming *Pseudo-nitzschia* species also reported for the first time from coast of Pakistan.

***Key words:*** Diatom; Seasonal abundance; species composition; HAB species; Manora Channel; Pakistan.

## 1. Introduction

### *1.1 Primary producers*

Diatoms are a large and diverse group of single cell algae and are classified under the division Bacillariophyta [42].

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They are distributed throughout the world in nearly all types of aquatic systems, constitute major proportion of the microbial community and are one of the most important food resources in marine ecosystem [5,36,46]. The bacillariophytes (diatoms) constitute a major proportion of the primary productivity in the ocean. The primary production (phytoplanktons) is the major energy source which drives the whole food web [11]. The primary producers (diatoms) are utilized by the consumers (zooplankton) which in turn serve as food for small fish and shrimp and also leads to larger fish upon which men relies for food [38,65,66].

### *1.2 Environmental impact on diatoms*

Diatoms appear when nutrient concentration, salinity and wind velocity are high and their colonization occurred due to the sea water inflow [22]. Silicate is the limiting nutrient and the abundance of diatoms is strongly related to the silicate availability. Development of diatoms communities is also governed by other physical factors like mixing depth, and turbidity; later being implicated with light condition [20]. It has been observed that strong stratification favors dinoflagellates and a turbulent regime is favorable for diatoms [52,53,54].

### *1.3 Carbon fixation and global warming*

Approximately 20-25 % of all organic carbon fixed of the earth is carried out by diatoms. Although diatoms remove $CO_2$ from the atmosphere through the process of photosynthesis and convert it into organic molecules, but it is interesting to note that excess $CO_2$ in the atmosphere decreases the diatom counts [1]. This means that $CO_2$ built up in the atmosphere would weaken the biological removal system. Consequently the global warming will increase as $CO_2$ is a greenhouse gas. Global warming is changing the global thermohaline circulation pattern in the oceans. For example, it alters the cold water sink in the North Atlantic and around Antarctica causing restricted transport of nutrients and heat to the Northern Pacific Ocean. This causes nutrient depletion at the poles where diatoms compete out with other types of algae; diatoms being more tolerant to colder temperature. Similarly, melting ice on Himalayas alters land-sea temperature/pressure differential that would cause upwelling of nutrient rich waters in the Arabian Sea thus alternating the food chain[1]. This results in blooms of photosynthetic organisms and subsequent oxygen depletion in the area [56,57].

### *1.4 Indicators of water quality and environmental changes*

It is well known that diatoms are sensitive to a wide range of environmental variables and that their community structure may quickly respond to the changing physical, chemical and biological conditions in the environment [45]. Diatoms can provide very useful information regarding the biotic integrity of aquatic ecosystems therefore they can be used as water quality indicator that would help in environmental management [7]. Their siliceous remains are used extensively as environmental indicator in studies of climate change, acidic precipitation, water quality and palaeolimnology.

### *1.5 Eutrophication and Algal growth*

It is generally known that in marine and esturine systems nutrients are the limiting factor for the growth of diatoms and other micro-planktons [18,64]. Nutrients added variably to the marine systems through upwelling of nutrient rich waters, rivers and anthropogenic activities causes change in the abundance and species composition of diatoms from place to place and with seasons [17,29]. Nutrient loadings triggers microalgal blooms including harmful algal species; the later being of particular importance as it implicates with the human and environmental health and safety [21]. Environmental selection of phytoplankton species is associated with the relative availability of specific nutrients. For example, diatoms, mostly non-toxic, require silicate which is not abundant in sewage effluents therefore diatoms growth in these waters ceases, whereas other phytoplankton classes which have more toxic species can continue to proliferate forming blooms [13,19,29]. It is well known that marine environments subject to low water turnover rate tend to develop high algal biomass and subsequently eutrophication [27]. There is a worldwide concern over increasing rates of coastal eutrophication as well as harmful algal blooms [2,3,4,26].

### *1.6 Biosilification in Oceans*

Diatoms are the great contributors to biosilification in the oceans. Silicon is the major limiting nutrient for diatoms growth and hence is a controlling factor in primary production . Thus the availability of silica for growth is a key to the diatom productivity. Since silicone, as silicic acid, is required by diatoms its supply into the photic zone mainly through silica dissolution and upwelling appears to control diatom production over vast oceanic areas. Major portion of the raw material for mineralization in natural diatom community is supplied by dissolution of dead cells. Silica dissolution appears to be controlled by temperature, zooplankton grazing, diatom aggregation and bacterial assemblages [37]. The recycling of silicon is very important for the proper and healthy functioning of diatom communities but it is a slow process dependent upon temperature and bio-geo equilibrium.

### *1.7 Hydrographical conditions of the Arabian Sea and study area*

The Arabian Sea is distinguished by seasonally reversing monsoonal winds, the resulting mixing and upwelling causes nutrient enhancement and affects the seasonal abundance, species composition and biomass of microbial communities in the region [28,48], therefore the Arabian Sea could be considered as an ideal environment for the study of the hydrographical conditions and their affects on variability of natural microbial community [40,61]. The seasonal reversal of surface currents in the Arabian Sea in response to the monsoon winds is a unique example of wind driven oceanic circulation [66]. During the summer or southwest monsoon (SWM), which typically occurs from June to September, the surface circulation is anticyclonic [6]. Strong upwelling takes place and brings cold nutrient rich waters to the surface which is responsible for the high primary productivity and downward vertical fluxes of organic particulates [31]. The coastline in Pakistan extends from the eastern edge of the Indus delta to Gawatar Bay (Jiwani) where the Dasht River discharges into Sea covering about 1050 km. The exclusive economic zone (EEZ) extends 0.202 million $Km^2$ in the Arabian Sea. Human activities are main cause of pollution resulting in an imbalance in ecosystem of the coastal areas [10]. Large amounts of untreated industrial and domestic sewage discharge into the sea via Malir and Layari rivers and other small ephemeral rivers and tributaries. Pollution together with hydrological processes can cause a rapid change in the populations and hence the area is subject to eutrophication. Manora Channel located on the estury of Layari River is one of the major coastal areas of Karachi that is facing the threats of pollution [10].The Layari

River discharged into the Manora Channel a highly polluted mixture of sewage from the north and west of the city and industrial effluents from Sindh industrial trading state (SITE) and the industrial areas of north Karachi. Approximately 3.5 million cubic meter of sea water circulates into the channel daily through the tidal flow, which is not effective to flush out the pollution load coming from the Layari River. This pollution load stays in the Channel and remains stagnant for sometimes [12].The species diversity at this area shown heterogenetory because the Manora Channel is the meeting place of two different water bodies, one from Layari River and other from the shelf and according to [39] such areas are heterogenous in species diversity. The Manora Channel is also highly affected by oil pollution because of its close location to the oil terminal, wharves, the fish harbor. Coastal areas differ significantly from open sea in their physical, chemical and biological features. They are characterized by instability of environmental conditions because of connected to land, whereas the environment is relatively uniform in open Ocean. Thus annual phytoplankton cycle is bimodal in open sea but polymodal in coastal areas of temperate latitudes. There is no significant information on chlorophyll distribution from coastal waters of Pakistan and the northern part of Arabian Sea, and is a neglected area till now. Only few reports are available on diatoms taxonomy, distribution and their seasonal abundance from the northern Arabian Sea [15,16,49,50,41,62,35,42]. A proper taxonomic assessment of bacillariophytes from Pakistan is lacking particularly in relation to seasonal and environmental changes taking place in this region. There are two phenomenon taking place parallel along the coast of Karachi one is the unique feature of reversal of monsoon system [6] the other one is increasing pollution. These two features continue affecting the primary productivity of the area. These hydrographical changes are sufficient to change the seasonal abundance, biomass and composition of diatom species along the coast of Pakistan. Marine pollution is the common threat and a worldwide problem, which is also facing by the coast of Karachi, Pakistan. This feature changes the community structure directly by changing competition among diatom species for nutrients and by decreasing silicate which diatoms require to form their cell wall. When diatom growth increases they died and sink and silica deposits. As a result silica level decreased. It can limit growth and cause species changes from heavy silicified to less silicified types of diatoms. The changes in the species composition of diatom community can have enormous consequences for higher animals like fish and other grazers of the marine ecosystem. Present study will provide detailed account of diatom community including centric and pennate types of diatoms till species level inhabiting coastal waters of Karachi.There is a need for developing a regular monitoring program that can point out the seasonal changes of diatom communities in the coastal waters of Karachi. The recent research on diatoms will provide the details of seasonal abundance, species composition, growth rate and taxonomy of toxic diatom species related with the changing behavior of this community over a gap of three decades along Karachi coast.

### *1.8 Aim of the investigations*

The paper presented here is a first comprehensive research on diatoms community structure, functioning and its response to the various physicochemical parameters of Manora channel (North Arabian Sea). This research overall objective is to analyze population structure of bacillariophytes and how their abundance and composition vary seasonally. One of the main aims of studies of diatoms ecology is to be aware of the factors that regulate phytoplankton production and their seasonal succession in marine ecosystem of costal waters of Karachi, Pakistan. It also includes taxonomic identifications of diatom species through light (LM) and scanning microscopy (SEM) for better understanding the pollution tolerant and toxic species from regional waters. An important objective of present studies is to evaluate the growth rate of natural diatom communities from Pakistani waters. The growth rate data reflects on the turn over of diatom species and hence primary productivity of the water column.

## 2. Methedology

Sampling was done bimonthly from May 2002 to July 2003, July, 2007, November, 2008 at the Manora Channel located on the estuary of Layari River. The study area represents the coastal waters of Karachi from where industrial effluents entering the Channel and causing the coastal pollution in the vicinity of the city. Samples of water were taken at two station established for regular sampling (Figure 1). **Station A,** Manora Channel (inside) a polluted area with impact from Layari River and mangrove ecosystem (24˚49.77'N 66˚57.85'E). **Station B,** Outside Manora Channel (open waters) a relatively non-polluted station with more oceanic ecosystem influence (24˚47.93'N 66˚58.87'E). Water parameters like temperature (thermometer), salinity (refrectometer), dissolved oxygen (DO; Wrinkler's method: Hanna C100), pH (Hanna HI9023, Italy) and chlorophyll a were also measured and correlated with total abundance of diatoms at both stations A and B. For the analysis of chlorophyll a 250mL of sample were passed through GF/F filter papers and extracted with 90% acetone solution, then analyzed spectrophotometrically [51]. Samples for scanning electron microscopy (SEM) were prepared for SEM by $KMNO_4$ oxidation method [55]. Estimation of diatom growth rate was done using *in situ* incubation method (Furnas 1990). Growth rates of total community and diatom species were calculated from increase and decrease of cell numbers by following formula

$\mu$ (doublings $d^{-l}$) = (l/T) log (T24/T0)

Where,

T is the incubation period (d) and T0 and T24 are the initial and final cell numbers. For consistency, all growth rates are expressed on a log basis (doublings $d^{-l}$). No growth rates were calculated when a species was not observed and net loss occurred in the samples.


**Figure 1:** Map showing the sampling location of Manora Channel Karachi coastal waters (Red dots) 1 as A and 2 as B [37].

## 3. Results

### *3.1 Ecological studies*

Ecological studies included the seasonal abundance of diatom, species composition and variations in physico-chemical properties related with it. This variation was due to the influence of monsoon system existing in the region. Primary productivity and hydrographical parameters in the northern Arabian Sea are greatly affected by the monsoon system that prevails from May to October for southwest monsoon and between November and March for northeast monsoon (Tab 1). The total phytoplankton community was dominated by diatoms [42]. Seasonal change in chlorophyll a has shown a strong negative correlation with diatom abundance. Highest total average abundance of pennate diatoms was observed at both stations as compared to centric diatoms. Statistical analysis shows overall lower species diversity from 0.1 to 3.6 at both stations (Figure 2). The analysis of chlorophyll during the study period showed highest value in the season of summer in the month of June, 2002 ((Tab 1). During this time total abundance of diatom population abundance was very low. High values of chlorophyll a and low abundance suggests that picoplanktons were dominating component at that time. Distribution pattern and seasonal variations in cell abundance of dominant, abundant, frequent and rare species were observed, in which seven dominant species were recorded from station **B** and six dominant species from station **A** (Figure 4). Among both centric and pennate diatoms, the genera *Chaetoceros affinis*, *Pleurosigma* sp, *Thalassiosira* sp, *Navicula directa* and *Nitzschia longissima, Rhizosolenia setigera, Thalassionema nitzschoides* remain dominated all year although seasonal variations in their cell abundance were observed (Table 2). Growth rate of diatoms was analyzed by 24 hours *in situ* incubation technique. Sampling was done at two stations, station A located inside the channel and station B outside the channel**.** The diatom species dominated in the community were *Nitzschia closterium, Nitzschia longissima, Pleurosigma* spp and *Thalassiosira* sp. Total community growth rate was negative -0.11$d^{-1}$ in summer and -0.7 $d^{-1}$ in winter but individual species have given positive response of growth even in the presence of grazers (Fig 4). The growth or production of phytoplankton indirectly shows the pressure of grazers on the microbial community because micro zooplanktons play a significant role in the marine food web and these are the organisms graze on phytoplankton. During the summer months the differences observed from the winter months may have been due to differences in microzooplankton composition, it suggests that this is a major factor determine the growth rate of diatoms in summer and winter.

**Table 1:** Average (Mean±SD) salinity (psu),temperature (◦C), dissolved oxygen (DO, mg/L), chlorophyll *a* (µg/L), pH and transparency (cm) from stations A, B [42].

| *Station* | *Salinity* (psu) | *Temperatue* (◦C) | *Dissolved Oxygen* (mg/L) | *Chlorophyll a* (µg/L) | *Transparency* (cm) | |
|---|---|---|---|---|---|---|
| *A* | **34-40** | **23.5-31.8** | **0.7-5.1** | **2.3-73.5** | **22-81** | **6.3-8.3** |
| | **37.1±1.5** | **27.3±2.8** | **3.0±1.4** | **14.9±14.3** | **43.4±17.0** | **7.4±0.4** |
| *B* | **34-41** | **22.3-31.1** | **2.3-5.2** | **0.4-103.2** | **27-207** | **6.6-8.1** |
| | **37±1.6** | **27.3±2.6** | **4.0±0.9** | **13.3.±20.2** | **83.7±49.3** | **7.6±0.4** |

**Table 2:** Seasonal abundance (Cells/lit) of pennate and centric diatom species from coastal waters of Karachi.

| | | | | | |
|---|---|---|---|---|---|
| | **Diatom species** | | | | |
| | ***Pennate taxa*** | | | **A** | **B** |
| | | | | **(10^3 cells/lit)** | |
| | *Amphora sp* | | *** | 3.86 | 11.48 |
| | *Asterionellopsis glacialis* | | ** | 5.48 | 2.4 |
| | *Asterionella Formosa* | | *** | 19.46 | 15.34 |
| | *Cylindrotheca clostrium* | | *** | | 6.66 |
| | *Gyrosigms* sp | | ** | 2.4 | 0.4 |
| | *Licmophora paradoxa* | | | 0.14 | |
| | *Nitzschia longissima* | | **** | 1196.1 | 1677.62 |
| | *Navicula directa* | | **** | 489.7 | 884.36 |
| | *Navicula transitranse* | | | 82.92 | 13.72 |
| | *Navicula f delicatula* | | | 1.6 | |
| | *Navicula* sp *6* | | *** | 6.14 | 6.42 |
| | *Pseudo-nitzschia* sp | | *** | 136.74 | 68.66 |
| | *Pleurosigma* sp *1* | | **** | 34.7 | 45.9 |
| | *Pleurosigma* sp *2* | | ** | 43.76 | 4.96 |
| | *Pleurosigma directum* | | * | 0.14 | 0.14 |
| | *Pleurosigma normani* | | * | 2 | 0.54 |
| | *Pinnularia sp* | | ** | 2.58 | 5.04 |
| | *Pleurosigma macrum* | | | 0.14 | 3.2 |
| | *Rhizosolenia setigera* | | *** | 65.34 | 76.52 |
| | *Rhizosolenia imbricata* | | ** | 15.98 | 6.52 |
| | *Synedra* sp | | ** | 11.74 | 6.92 |
| | *Thalassionema nitzschiodes* | | *** | 43.8 | 38.42 |
| | | | | | |
| | ***Centric taxa*** | | | | |
| | | | | | |
| | *Coscinodiscus radiatus* | | * | 1.2 | 0.4 |
| | *Corthrone criopilum* | | * | 0.6 | 0.28 |
| | *Chaetocerose danicus* | | ** | | 3.72 |
| | *Chaetocerose decipience* | | ** | 1.46 | 4.16 |
| | *Chaetocerose affine* | | **** | 102.4 | 368.44 |
| | *Ditylum brightwilli* | | * | 16.92 | 0.4 |
| | *Guinardia flaccida* | | *** | 6.82 | 20.82 |
| | *Guinardia striata* | | *** | | 15.28 |
| | *Eucampia zodiac* | | *** | 47.2 | 100.92 |
| | *Odontella sienensis* | | *** | 5.34 | 39.72 |
| | *Odontella aurita* | | *** | 60.8 | 15.6 |
| | *Odontella mobileinsis* | | ** | 1.72 | 8.3 |
| | *Planktoneilla sol* | | ** | 2.14 | 1.22 |
| | *Skeletonema sp* | | * | | 0.4 |
| | *Thalassiosira sp* | | **** | 11.48 | 23.98 |
| | *Triceracium sp* | | * | | 0.4 |
| | | | | | |
| | **** | Dominenet species. | | | |
| | *** | Abundant | | | |
| | ** | Frequent | | | |
| | * | Rare | | | |

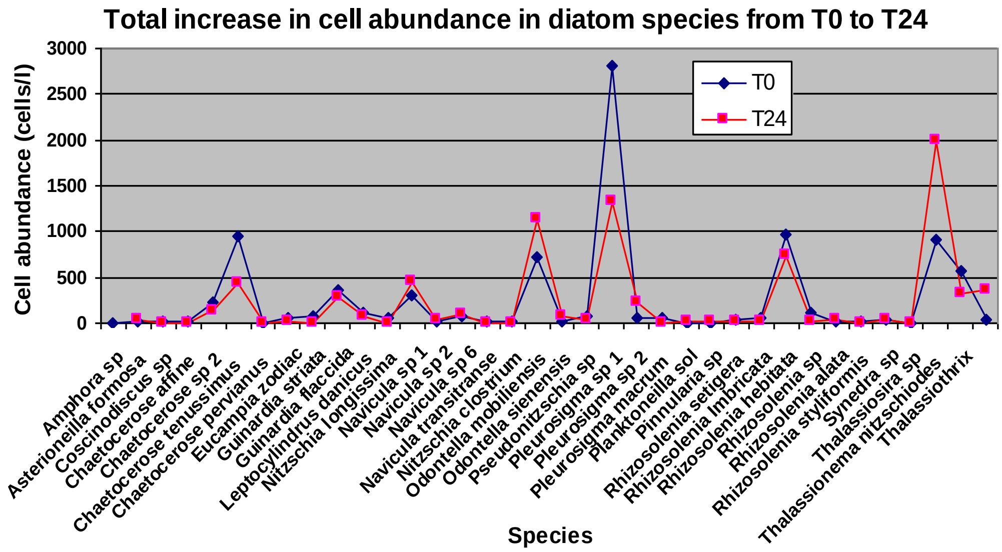


**Figure 5:** Increase in cell abundance of diatom species at T0 (initial time ) and after 24 hours T24 (final time).

### *3.2 Statistical analysis*

**Shannon and weaver diversity index (H′):** Shannon and Weaver (1949) diversity index (H) was calculated (Figure. 2) by the equation:

$H' = -\Sigma\, Pi\ 1n\ Pi$

*Where,*

*H′ = Diversity Index, pi = Relative percentage of specie*

***Species richness index (d):*** *The equation below was used for calculating species richness.*

$d = (S - 1)/ \text{Log } N$

*Where,*

*d= Species richness index, S = Number of species in a population, N = Total number of individuals in species.*

***Species equitability***

$j = H' / \text{Log2 } S$

*J = Equitability index, H′ = Shannon and weaver index, S= Number of species in a population.*

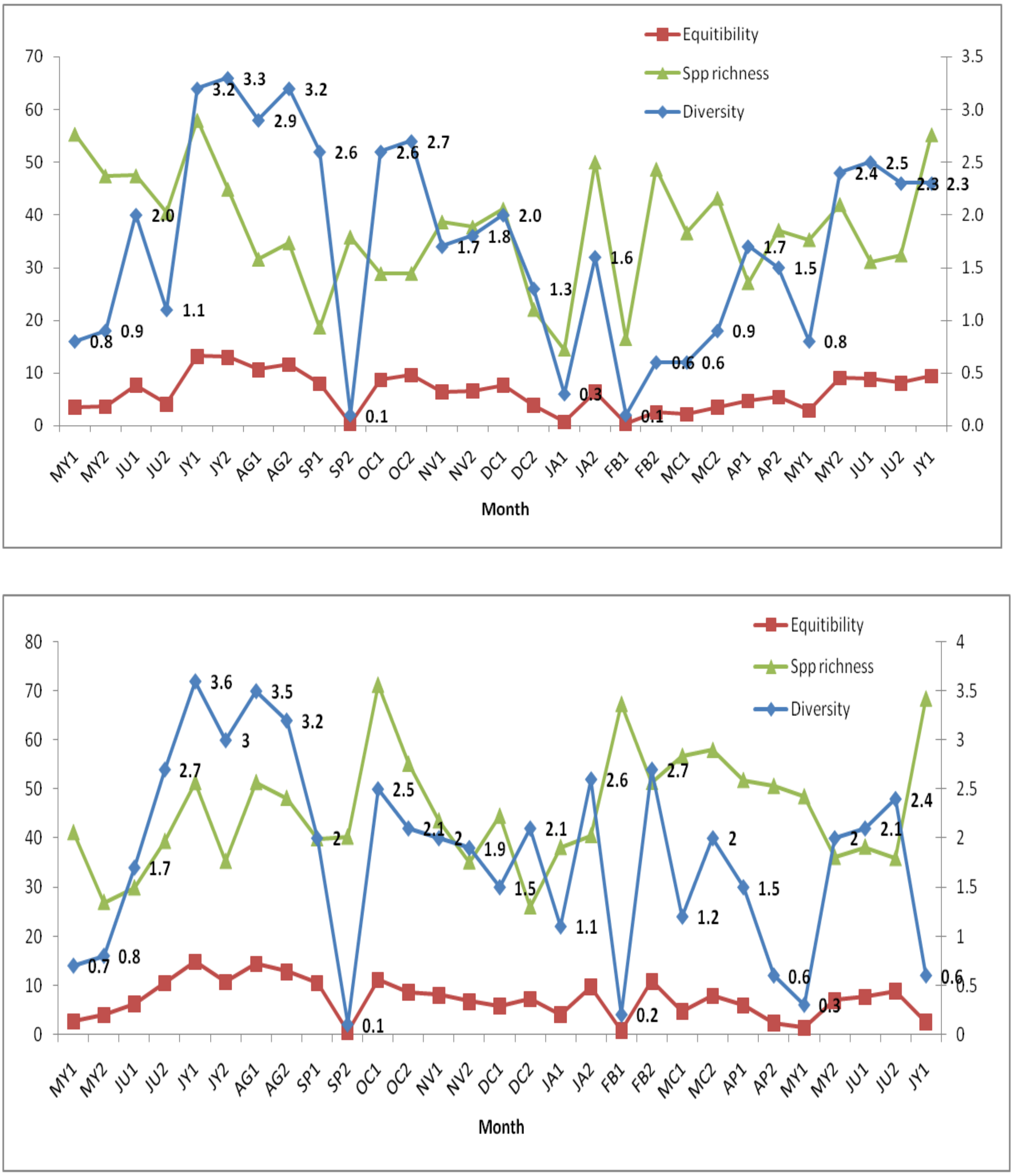


**Figure 2:** Diversity, species richness and equitability from station A, B. [42].

Regression analysis was applied to show the relationship between diatom cell abundance and water parameters (Figure 3).

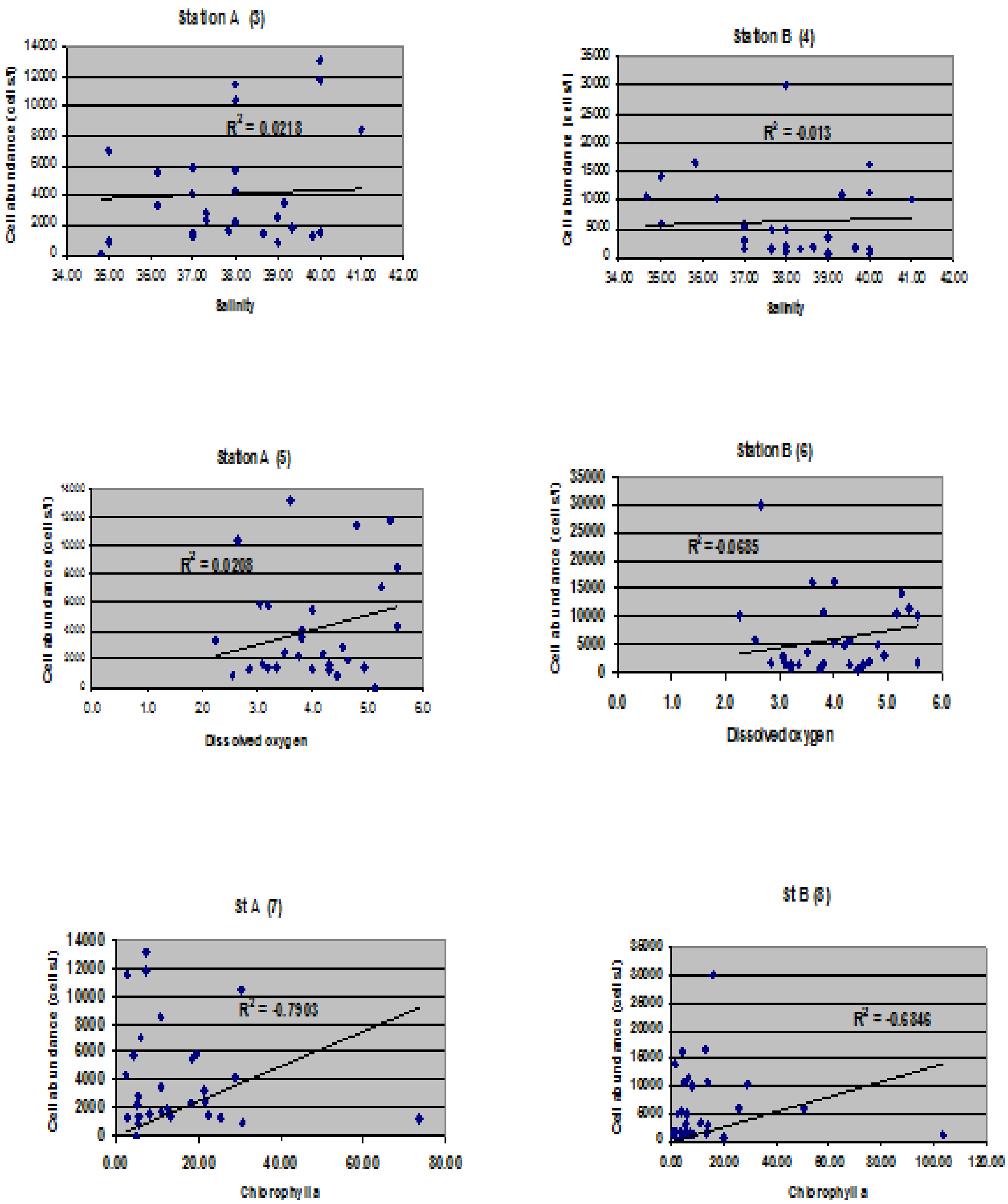


**Figure 3:** Regression analysis of between total cell abundance of diatom and water paprameters.

( 1, 2. Temperature, 3, 4. Salinity, 5, 6. Dissolved oxygen, 7,8. Chlorophyll a).

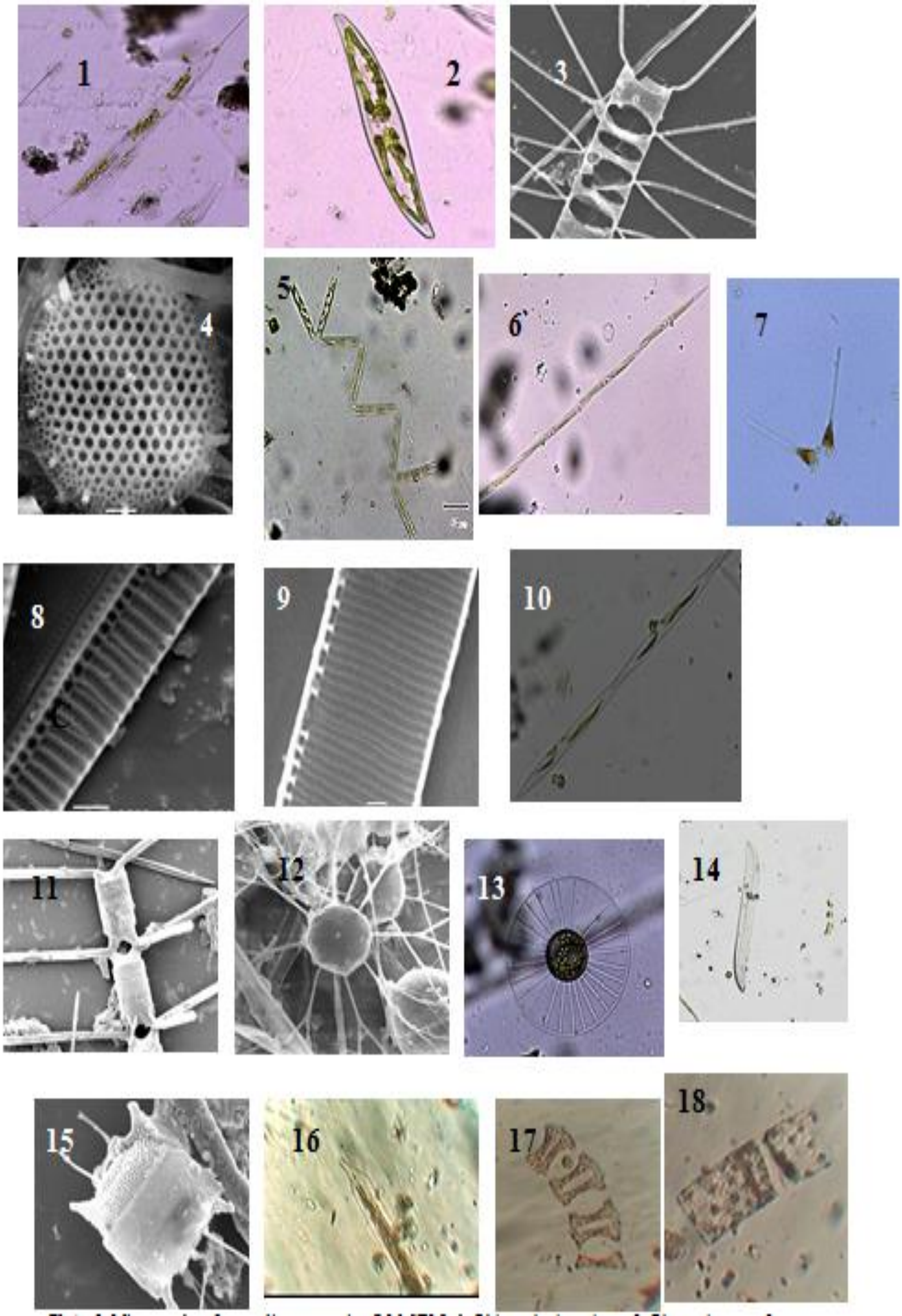


**Figure 4:** Micrographs of some diatom species (LM, SEM). 1. *Rhizosolenia setigera*, 2. *Pleurosigma sp,* 3.Chaetoceros decipience, 4. Thalassiosira sp, 5. Thalassionema nitzschoides, 6. Pseudo-nitzschia sp, 7. Asterionellopsis glacialis, 8. Pseudo-nitzschia pungens, 9. Pseudo-nitzschia fraudulenta, 10. Pseudo-nitzschia subfraudulenta, 11. Chaetoceros borealis, 12. Bacteriastrum delicatulum, 13. Planktonella sol, 14. Pleurosigma balticum, 15. Odontella mobiliensis , 16. Rhizosolenia alata, 17, Eucampia zodiacus, 17. Guinardia flaccida [41].

### *3.3 Taxonomical studies*

During the taxonomical studies toxic *Pseudo-nitzschia* species were detected in the samples. The taxonomical differences were observed for *Pseudo-nitzschia pungens*, *P. fraudulenta* and *P. subfraudulenta*. Their seasonal abundance was also calculated [43]. This investigation showed that *Pseudo-nitzschia* species have comparatively high abundance at station A located inside Manora Channel and this could be attributed generally to the influence of domestic and industrial effluents being regularly pumped in through Layari River. The increasing trend of eutrophication in the region due to these river inputs benefits the harmful species to proliferate and form blooms. *Asterionella glacialis* and *Coscinodiscus welsii* (c.f) known as bloom forming species also observed during investigation. *Coscinodiscus welsii* (c.f). *Coscinodiscus wailesii* considered as a massive bloom forming diatom species found with high carbon biomass values from Pakistan waters, but its morphology has not been described before from this area. *Asterionella glacialis* (Figure 4) is reported as a bloom forming diatom species from many regions including Pakistani coastal areas [25,33] but considerably lower cell abundance was encountered from Manora Channel during our study period. This could be due to the increasing trend of pollution along the channel during the last two decades. Manora Channel, from where the samples were collected, also faces effluent discharges and sewage inputs from Layari River causing eutrophication in the area.

## 4. Discussion

Diatoms are the most important food resources (primary productivity) in marine ecosystem and approximately 20-25 % of all organic carbon fixation of the earth is carried out by diatoms [1]. The primary production is the major energy source which drives the whole food web, so the knowledge related to the diversity of diatom community is very important for the assessment of food web structure and water quality. Algal community abundance, species composition and their growth changes with time scale influence the local fisheries [12]. The abundance, biomass and species composition changes are linked with the physicochemical parameters prevails in the area. For the understanding of primary production and their correlations with the environmental variables it is imperative to have knowledge about the primary producers (diatoms) and their functioning in the region. Hence the present study will provide detailed account of diatoms community including their seasonal abundance, species composition, taxonomy and growth of diatoms inhabiting coastal waters of Karachi. The Arabian Sea is well known for seasonal monsoonal system, results in mixing of different water bodies due to upwelling during south west and northeast monsoon periods [66]. Strong upwelling and deep mixing raise the silica concentration that favors the diatoms growth. During our investigations two diatom blooms were observed in late monsoon periods shows the influence of hydrographical changes on the microalgal community. Recent reports also described the bloom formation and high species richness in North Arabian Sea every year during monsoon period [59,23] which is in good conformity with the observation recorded in the present study. Seasonal variations in the abundance were clearly seen throughout the study period from May, 2002 to July, 2003. Diatoms survived throughout the year under all temperatures and salinities constituting major part of phytoplankton (personal communication). Similar high proportion of diatom in total phytoplankton have been recorded from Omani coast in the northwestern Arabian Sea [9,11] and from the west coast of India [46].Two peaks of cells have seen because of a single species in September, 2002 (Southwest monsoon period) at station

B and in February, 2003 (northeast monsoon period) at station A. Seasonal succession of physicochemical parameters like salinity, temperature, dissolved oxygen and pH were monitored during the study period. Seasonal change in chlorophyll a has shown a marked seasonality and has strong negative correlation with diatom abundance. High cell abundance at station B as compared to station A showed that polluted station A had low abundance compared to relatively non-polluted station B. Overall low species diversity (diversity index) 0.1 to 3.6 at both stations may be due to the high organic loads which has been shown to reduces the abundance and diversity of diatom communities and as a result domination of few species in the area was observed which is in the agreement with an earlier study [63]. The coast of Karachi consistently facing two features, one is the reversal of monsoon systems and the other is increasing pollution. These two features continue to affect the primary productivity. These hydrographical changes are sufficient to change the abundance, biomass and composition of diatom species along the coast. Manora Channel located on the estuary of Layari River is one of the major coastal areas of Karachi exposed to industrial and sewage pollution. The Layari River drains into the Manora Channel a highly polluted mixture of sewage from the north and west of the city and industrial effluents from Sindh industrial trading state and the industrial areas of north Karachi. Approximately 3.5 million cubic meter of sea water circulates into the channel daily through the tidal flow, which is not affective to flush out the pollution load coming from the Layari River. The pollution load of Layari dilute out through the semidiurnal tidal flushing. The mixing of two waters results in heterogenous diatom community [39] including both centric and pennate species having typical temperate, tropical, subtropical and cosmopolitan species. Total of fourty one species was differentiated morphologically including both centric and pennate types. The identified diatom composition showed typical temperate, tropical, subtropical and cosmopolitan species. Seven dominant species were recorded from station B and six dominant species from station A. Among both centric and pennate diatoms, the genera *Chaetoceros affinis, Pleurosigma* sp 1, *Thalassiosira* spp, *Navicula directa* and *Nitzschia longissima*, *Rhizosolenia setigera, Thalassionema nitzschoides* remained dominated all year although seasonal variations in their cell abundance were observed for these species. These species also observed as a major component of diatom community from other regional areas, for example west cost of India (Eastern Arabian Sea), [46], Gulf of Oman, western and central Arabian Sea, [58], Bay of Bengal [47] and East China Sea northeast of Taiwan [60]. Present study is the first detailed record of bloom forming toxic species namely, *Pseudo-nitzschia pungens*, *Pseudo-nitzschia fraudulenta and Pseudo-nitzschia subfraudulenta* including their seasonal abundance and taxonomic identification from coastal waters of Pakistan [44]. HABs (harmful algal bloom) species are increasing worldwide because of increasing pollution and eutrophication phenomenon. Our study area (Manora Channel) is also facing the problem of eutrophication and the presence of the toxic species showed the possible relation of these species abundance with nutrient enrichment. *Pseudo-nitzschia* species are the common members of diatoms and according to recent research confirmed for the production of a neurotoxin domoic acid. The accumulation of domoic acid (DA) cause the paralytic amnesic shellfish poisoning (PSP, ASP) which enters in food chain and results in mass mortality of higher consumers in coastal areas throughout the world. The present investigations showed that *Pseudo-nitzschia* species has comparatively high abundance at station A located inside Manora Channel and this could be attributed generally to the influence of domestic and industrial effluents being regularly pumped in through Layari River. The increasing trend of eutrophication in the region due to these river inputs benefits the harmful species to proliferate and form blooms. The sampling area is also influenced by the upwelling phenomenon. These processes of anthropogenic factor and natural upwelling caused by monsoon system are enough to alter the diatom community and encourage the development of toxic species. During our studies a massive bloom forming diatom species *Coscinodiscus* c.f *wailesii* is also identified with high value of carbon biomass. This is an alarming condition for the fisheries industry because bloom conditions of this species could result in sharp decrease in oxygen concentrations and hence affect the survival of other organisms [30]. The major reasons for incidents of mass mortality of fish in the coastal waters of Karachi could be the due to the depletion of oxygen, direct intake of toxic algal species. The possible occurrence of massive bloom in coastal waters call for regular monitoring of toxic species and toxins in water and fishery product ensure product and health safety. Growth rate of diatom were calculated using 24 h *in situ* incubation technique. Sampling was done in two different seasons, summer and winter at the mouth of the Channel during February, 2006 and May, 2007. Total community growth rate was negative ($-0.11d^{-1}$) in summer whereas ($-0.7\ d^{-1}$) at station B but positive ($0.1d^{-1}$) at station A in winter. The individual species have given positive growth even in the presence of grazers. It appears from the data obtained by the experiments that when the large grazers were removed from the samples by prescreening with 150µm and 10 µm the diatom growth increased. It suggests high grazing pressure on diatom community which could be responsible for negative rate of diatom growth. Intense grazing pressure was observed from central Arabian Sea by [8,9,34]. A convincing explanation is given by [9] from central Arabian Sea Oman, those large copepods for instance *calanoids carinatus* present in the upwelled waters during the period between southwest monsoons. These hungry copepods are in large numbers and grazing together with the microzooplankton prevented the accumulation of diatom biomass. Similar observation was made by [24] from Australia GBR (Great Barrier Reef) subtropical waters and [34] from eastern Pacific Ocean. This suggestion is supported the hypothesis given by [14,32] that pattern of abundance and species growth vary significantly and could be controlled by the grazers rather than nutrient availability. Further investigations required for the estimation of grazing pressure on diatom community. Present research has contributed in the field of diatoms studies neglected for many years from this region. It represented and covered the seasonal abundance, species composition, biomass estimation, growth rate and taxonomical studies. This work will provide initial information and guideline for future investigations and there is still a need of better understanding regarding the diatom communities and a long-term monitoring program should be initiated.

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