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Seasonal Diatom Density Investigation of the Mersin Rivers

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Abstract— **In Mersin (Tarsus-Anamur Coastline), four seasons' vegetation samples are gathered from around 20 estuaries and diatom percentages are determined. Mostly Navicula, Pinnularia, Gomphonema, Synedra, Nitzchia and also Triceratum, Cyclotella, Cymbella, Coconeis, Diatoma, Amphora, Gyrosigma, Licmophora species have been observed. The other determined organisms are bacteria and algae parts, as Vaucheria, Pediastrum, Pandorina, Peridinium, Phacus and Euglena which are seen in almost all rivers, and Ankistrodesmus, Kirchneriella species, which are found in Kuyuluk Creek.Over the past two years, the Metropolitan Municipality paved the river-beds with concrete to prevent flooding, and depending on the increased population and settlement, water pollution has started to emerge. That is why the periodic inspections are of the utmost importance. For 2013-2014, the data of Paşasuyu, Göksu and Tarsus rivers demonstrate a clearer picture. We believe that this research will increase the interest in the river ecosystems of Mersin, contributing to future researches in this field.**

Index Terms— **Diatoms, Mersin (Tarsus-Anamur) coastline, Mediterranean Sea.**

I. Introduction

Diatoms, besides the role of environmental condition indicator, also determine the water quality and are as interesting and intriguing phytoplanktons, as snowflakes. They took a primary role in various studies, in terms of Oxygen, nutritional value and pollution indicator. For example, Qiu et al. (2002), the Aboal et al. (2010), studied on Nostoc colony, and Bertalot & Alles (2007) discovered that Eunotia minor and Eunotia implicata are found in 78 localities of Spain, in high densities [1-3].

Nahar et al. (2010) investigated the seasonal diversity of diatoms; Yılmaz et al. (2007) have published the feeding habits of fishes in Bafra Lake [3, 4].

Venkatachalapathy et al., among the species found in the Yercaud lake, the species belonging to genera Navicula, Gomphonema, Nitzcshia, Pinnularia are reported and associated with relatively clean to less polluted waters. These species are reported from less polluted, tolerant and associated with natural substrates i.e. macrophytes [5].

In the Mediterranean region, Álvarez-Blanco et al., [6] stated 73 different species of benthic diatoms within a book. Yahia-Kef et al. [7] examined the seasonal flow of the dominant species of diatoms and dinoflagellates in the Tunisian coast, while publishing the list of the diatoms in the Aegean Sea, on the web page. (http://www.diatomloir.eu/site%20diatom/list%20diatoms%I 20fro% 20 Mediterrane the 20Sea.html%).

Solak and Wojtala [8], identified that the five rivers located in Sakarya, Türkmen mountains contain more than 300 diatoms in the spring, and found that out of 245 identified taxa, 59 were also common in other known distributions of Turkey. In this study, we investigated only Antalya / Burdur and Adana regions, as a part of Mediterranean.

Amphora ovalis, Cocconeis pediculus, Cocconeis placentula were detected in Antalya. Euglypta rotunda, Craticula cuspidata, Cyclotella ocellata, Cymbella cymbiformis, Cymbella neocistula, Diatoma tenuis, Diatoma vulgaris, Cymatopleura solea, Gomphonema olivaceum, Gomphonema parvulum, Hantzschia amphioxys, Melosira varians, Meridion circulare, Navicula cryptocephala, Navicula radiosa, Navicula rhynchocephala, Nitzschia acicularis, Nitzschia fonticola, Nitzschia linearis, Pinnularia microstauron, Planothidium lanceolatum, Surirella angusta, Ulnaria ulna were also mentioned in the following publications, as reminded.

Everest et al. (btw. 1999-2015) investigated sea water, river algae and diatoms density of the regions between the Mersin Port & Erdemli Coastline [9-12]. In 2013, Ozbay et al., [13] carried out the investigation of heavy metal levels in the Berdan River sediments (Tarsus - Mersin).

The Almeida et al., emphasized the quality of water of the Mediterranean rivers. Aysel et al. and Bingol et al., investigated the epilitic diatoms. Bingöl et al., as Almedia et al. [14-16], stressed the important role of diatoms in monitoring river pollution.

Maraşlıoglu et al., [17] studied the social structure and seasonal changes of 36 Chlorococcales species found in the delta lakes of the Kızılırmak River during the 1996-2003 period. Ankistrodesmus falcatus and Kirchneriella obesa, Tatli, Gıcı and Port lakes were the most important species considering the Chlorococcales distribution. In Çernek Lake, Monoraphidium irregulare has reached its highest value in Chlorococcales structure. Especially in the winter season, a remarkable increase has been observed in the number of species of Monoraphidium and Ankistrodesmus, compared to other seasons.

Koçer and Şen [18], examined the seasonal succession of phytoplanktons in the Lake Hazar. While Epithemia, Rhopalodia, Cocconeis and Cyclotella were dominant in spring and autumn, Gomphonema, Fragilaria, Navicula and Nittzschia were found to be dominant in winter.

Gürbüz and Altuner [19], studied on the phytoplankton groups found in Palandöken Pond. Again, Tokatlı et al. [20] determined the levels of macro and micro elements given in

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the Porsuk dam pond water, sediments and diatom frustules, and compared the results with the Gürleyik creek, which is known as clean. While 25 taxa were identified in the Porsuk dam pond, 45 taxa were identified in Gürleyik creek. Consequently, it revealed that the water and sediments of the Porsuk dam pond were contaminated by metals, and that diatom frustules are accumulating some metals (Al, Fe, S, Zn, B, Cd, Cr, Cu, Mn, Ni, Pb and Si) more than the others.

Ozer and Pala researched Bozcaada marine flora and investigated the seasonal changes of phytoplanktons [21].

As already known, the structure and abundance of the phytoplanktons are affected by the light, temperature and nutrients conditions in the lakes, and by the flow and water velocity, in the rivers. Considering the epilitic and epiphytic algal composition of Pulur Stream, no significant difference was noted among the stations. Epilitic and epiphytic algae were stated to be found more near the river's source and fewer, near the mouth of the river [22].

Kıvrak et al., studied the Akarcay benthic diatoms and some of its physico- chemical properties, by taking samples on a monthly basis. It is found out that among the benthic diatom communities, Cocconeis placentula, Cyclotella meneghiniana, Encyonema minutum, Sellaphora pupula, Nitzschia tubicola, Cymatopleura solea, Amphora veneta, Amphora pediculus, Ulnaria ulna, Gomphonema parvulum, Gomphonema angustatum and Navicula cryptocephala were more dominant at the start of the creek, while Nitzschia palea were dominant in the lower parts. The same authors (2012), also stated that the water quality of the initial parts of Akarcay were moderately polluted in the spring, but critically polluted in summer. All calculated indexes proved that the initial parts of Akarcay were contaminated by the farming practices [23].

According to Sıvaci and Dere [24], the reason behind the frequent occurrence of species as Navicula cryptocephala, N. tripunctata, Cymbella ventricosa, N. amphibia, N. palea is the fast-flowing characteristic of Melendiz Stream. Similarly, the studies conducted in the fast flowing rivers of Europe also identified the same species as mentioned above. As Hynes (1974) stated that some species belonging to the genus species such as Cocconeis, Cyclotella and Campylodiscus were dominant along the river sides and in the bottom parts of the water where the flow rate is rather slow, and some other species (belonging to the Navicula, Achnanthes and Nitzschia genera) were found to be more common in fast flowing waters. In the Melendiz creek, Frustulia, Pinnularia and Surirella genera which have very high tolerance, multiplying in acidic waters, were found in small numbers. Number of organisms in the flora of the stations showed an increase in early summer, depending on the water temperature. A similar situation is also indicated for River Karasu (Firat) by Altuner and Gürbüz [25]. The number of diatoms in the flora starts to decline rapidly in the middle of summer. The reason is identified as the sudden increase in the number of diatoms in June-1993, and the parallel increase of the zooplanktons that feed on them.

In the selected 5 stations of Melendiz creek, the composition and seasonal changes in the density of the epilitic diatom flora were researched. Depending on the increased speed rate, the total number of organisms dropped in May, and due to the decrease of speed the number of organisms has increased in June. There is also found Cocconeis placentula var. euglypta, Navicula cryptocephala, Navicula tripunctata, Cymbella ventricosa, Nitzschia amphibia and Nitzschia palea were dominant species found in the Melendiz river [24].

Tokatlı and Dayıoğlu, [26] determined the epilitic diatoms of the Murat River, resulting in 70 Pennales and a total of 75 diatom taxa were identified, including 5 Centrales members. Nitzschia, Navicula, Cymbella, Gomphonema, Diatoma and Fragilarilaria genera were found to be dominant in the phytoplankton diversity. These include Cymbella affinis (13.31%), Gomphonema olivaceum (10.09%), Nitzschia palea (9.54%), Diatome moniliformis (9.01%), and Cocconeis placentula var. lineate (8.94%) and Gomphonema truncatum (7.91%) are the most dominant taxa. In Murat Stream, Pennales members -detected taxa belonging to the Bacillariophyta section- found to be more dominant compared to the Centrales members, in terms of both the quantity and the density of taxa. Similarly, the dominance of diatom communities in epilitic Pennales members has been identified by many researchers.

In Pennales group, Nitzschia were the main genus represented by the most species (12), and followed by the genus Navicula (8), Cymbella (6) and Gomphonema (6). Similarly, other researchers in have reported that they are the dominant genera. Navicula and Nitzschia were reported as the the most common genera found in freshwater, while Nitzschia species were said to be the richest genera found in organicaly contaminated waters which are rich in salt nutrient and poor in water oxygen [26].

Pala and Çağlar [27] investigated 'Peri Creek's epilitic diatoms in Tunceli for one year. In the investigated area, Gomphonema (6 species), Fragilaria to (5 sp.), Cymbella (4 sp.), Pinnularia, Achnanthes and Navicula (3 sp.) were identified as the main diatom genus represented by the most species. Additionaly, Cymbella, Gomphonema and Fragilaria species were noted in terms of the frequency of their occurrence and the epilitic forms of the populations.

Pennales members were stated as more dominant compared to their Centrales members, in terms of both the quantity and the richness of taxa. Epilitic dominance of algae communities in Pennales member has been demonstrated by other researchers [28-33].

Among Pennales group when studied in itself, the genus represented by most species has been stated as Nitzschia. This genus was followed by Navicula, Cymbella, Gomphonema, and the Surirella. Navicula, Nitzschia, Cymbella, Surirella, Gomphonema and Pinnularia were found to be intensive in Kızılırmak. Again, Kalyoncu (2002) in his studies in Aksu Creek stated that taxa belonging to Nitzschia, Navicula, Cymbella and Gomphonema were found to be intensive. Among the epilitic diatom given in Yukarı Porsuk Creek, Melosira varians, Navicula exigua, N. capitatoradiata, N. cuspidata, Nitzschia dissipata, Gomphonema minutum and G. olivaceum were detected as the other dominant taxa. These taxa were also reported in Meram Creek, Karasu River, Kızılırmak River, Samsun; İncesu Creek, Ankara Stream, Sana Creek, Çoruh River, also the Yesilirmak River, Çip Creek and Sarıçay [15, 29-33, 42-45].

Cymbella affinis were reported as having a decreasing dominance depending on the increasing pollution and an

increasing dominance in the clean, less contaminated areas where the water quality lies between the I-II [35]. Solak et al. [8], also stated that they were mostly found close to the source, where water is clean. In line with the studies of Bingol et al., Nitzschia palea or Melosira variance were identified to be seen due to the increasing pollution of the environment. Barlas et al., reported that in Sarıçay the river, Nitzschia palea were more dominant during the summer months compared to others, when the water is warmer and where the areas were critically contaminated [14, 29]. While Lange-Bertalot stated that this taxa were tolerant to toxic effects, Kalyoncu [28] stated that in Isparta Creek, this type can be classified with the quality level II-III. This study suggested that Melosira variance were mainly dominant in moderately contaminated areas. It was reported that this taxon showed a good growth rate in rather dirty parts of the river [31, 35, 36].

Mumcu et al. [34], identified a total of 63 taxa belonging to Bacillariophyta. Nitzschia (9), Cymbella (7), Navicula (6) and Gomphonema (5) have been the other species represented with the most taxa. The most prominent taxa were stated as Melosira variance (16.13%), Fragilaria ulna (8.84%), Cocconeis pediculus (7.54%), Diatome vulgaris (5.71%), Synedra tabulate (5.24%), Cocconeis placentula (4.89%) and Navicula tripunctata (4.87%). Navicula and Nitzschia were identified as the most common types found in freshwater, while Nitzschia were identified as the richest type found in organically polluted areas, where nutrients salt is rich and oxygen is poor.

In the Pulur Stream (Karasu Stream), samples taken from the water, stone, and plants, suggested that Diatoma vulgaris (40.67%) constitutes almost half of all species and followed by the Navicula cryptocephala to (13.23%), Cymbella affinis (% 7,27), Aulacoseria granulata (7.13%), Nitzschia sigmoid (6.30%) and Gomphonema olivaceum (5.62%), respectively. In our country, Cymbella, Diatome, Navicula and Nitzschia species were stated as the most common species within the inland waters and Nitzschia species were identified as the most abundant species found in nutrients salt rich waters [26].

In our country, the measurement of the ecological value of the rivers should be performed every ten years, based on the region, city, town and village / neighborhood-wise, as also emphasized by Bingol et al. [14], highlighting the Ramsar Convention. Pursuing this task and with the purpose of realising our part, Mersin's rivers were examined seasonally, for the first time.

II. MATERIALS AND METHODS

Starting from the Mersin to Anamur (Müftü Creek, Çiftlikköy, Kuyuluk, Kandak, Mezitli, Kargıpınarı, Tömük, Kocahasanlı, Karadedeli, Arpaçbahşiş, Paşasuyu, Göksun, Kapız, Lamas (Lamos), Göksu, Soğuksu, Sultansuyu and Dragon Rivers) were investigated by sampling of rivers in the autumn, winter, spring, summer vegetation periods where it flows into the sea. As some rivers dry out in the summer, analysis could not be completed for the 4 seasons. Tarsus (Berdan) which is used as drinking water source in Mersin, included in studies, the Kandak Stream was sampled and examined to be reported in a separate editorial content.

During these four vegetation periods, water samples taken from the mouth rivers were collected in plastic bottles and grouped/preserved in the laboratory in 100 ml glass jars. Temporary preparations are arranged for collected samples, and pre-counted. Later, these examples were fixed with formaldehyde of 4%, and investigated. Using Olympus BX50 research microscope, the average of diatom shells appeared in every 10 preparations were counted and taken the average. Relative intensity is made by comparing the individual number of type A with the number of individuals of all species, calculating the related percentage [37].

In the diagnosis Krammer & Lange-Bertalot [38-41] were used, and has been subjected to the percentage calculations and compared with the species living in the water sources.

III. RESULT AND DISCUSSIONS

Winter term population seems rich in all the rivers. Berdan (Tarsus), Paşasuyu, Kuyuluk and Müftü rivers are remarkable in terms of the type of content. However, these species are seen much reduced in summer. It is observed that the list of species are also subject to change every season. Considering the dragged number of species, the ranking can be given as; Berdan (Tarsus), Dragon, Kuyuluk, Paşasuyu, Kargıpınarı, Arpaçbahşiş, Göksu, Lamas (Lamos), Mezitli, Karadedeli, Müftü, Soğuksu, Sultansuyu, Çiftlikköy, Kandak, Tömük, Kocahasanlı.

Based on the density level, Navicula, Pinnularia, Gomphonema and Nitzcshia are found, indicating the change of rivers from less dirty towards clean [5] [Fig. 1-2, 6-7, 9-13; 20, 22, 25, 26, 28]. All reported dominant species are found to be in line with the findings of Tokatlı and Dayıoğlu [26] and of Sivaci and Dere [24]. Stating that Cylotella, Cymbella, Cocconeis, Diatoma, Amphora are detected in Antalya rivers, indicates a further consistence with Mediterranean streams [8] [Fig. 13-14, 16-19,23, 27-29]. Cyclotella which is dominant in Lake Hazar during the spring period, as well as in Antalya, is also determined to be found in Müftü, Çiftlik, Kargıpınarı and Paşasuyu [18] [Fig. 12, 13, 16-18].

Bingol et al. [14], determined that the species belonging to Navicula, Nitzschia, Cymbella, Sirurella, Gomphonema and Pinnularia were concentrated in Kızılırmak, and Cymbella affinis were stated to be found in the clean areas of the Porsuk River. In our study, Kargıpınarı, Arpaçbahşiş Rivers (in Erdemli); Soğuksu River (in Aydıncık); Dragon River (in Anamur) in winter; Göksu River in spring and Ciftlikköy River in autumn are identified as the clean water indicator, but also Gomphonema were reported which is rather resistant to pollution.

Again, Cymbella affinis, seen in clean areas, stated to be found in Lamas, Göksu, Paşasuyu, Arpaçbahşiş, Göksun Creeks, Karadedeli, Aydıncık and Anamur aquaparc/ rivers [Fig. 5, 9, 14-15, 20, 24, 26-33]. Nitzschia, being organic pollution-tolerant, is seen in all rivers during the summer, in Lamas, Paşasuyu the Göksu Rivers in rainless autumns, and partially observed in polluted waters of Kapız, Kandak and Lamas in the spring, together with Vaucheria. Maraşlıoğlu et al., determined that Ankistrodesmus and Kirchneriella are seen in Göksun Creek in the spring, as well as in Tarsus (Berdan) and Kuyuluk, while Amphora is seen in Paşasuyu, Kargıpınarı, Mezitli, Arpaçbahşiş and Karadedeli rivers [14,

17] [Fig. 24, 34, 35].

Sıvacı and Dere [24], stated that Cocconeis and Cylotella are mainly dominant around the river sides where the water flow is slow, and Navicula, Achnanthes and Nitzschia are found to be dominant in areas where the water flow is fast (eg. Göksu river) [Fig. 2, 10, 15, 21]. Pinnularia, Sirurella and Navicula species, having a high tolerance and multiplying in acidic waters. Sirurella, on the other hand, can be found in Berdan, Kargıpınarı, Müftü rivers in the autumn and winter time [Fig. 16, 20-23]. Also Fragilaria, being fond of low temperatures and high nitrogen / phosphate environment, can be seen in the Müftü, Kapız, Paşasuyu, Göksu and Soğuksu, in spring [Fig. 2, 3, 7, 13]. This occurance is supposed to be the result of agricultural activities carried out in the spring.

Melosira, identified as the indicator of pollution increase, is determined to be dominant in Porsuk and Isparta Creeks [15, 28, 32] and in Erdemli and Arpaçbahşiş, only in winter; and Epithemia is determined to be found in Mezitli, where the residential density is high [Fig. 26; 5].

As a result, Navicula, Pinnularia, Gomphonema, Synedra, Nitzchia, Triceratum were encountered plenty. Besides, the genera of Cyclotella, Cymbella, Coconeis, Diatoma, Amphora, Gyrosigma and Licmophora are observed.

The other determined organisms are Cyanophyta, Euglenophyta, Chrysophyta, Chlorophyta members (Vaucheria, Oedogonium, Pediastrum, Pandorina, Peridinium, Phacus, Euglena, etc.).

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APPENDIX

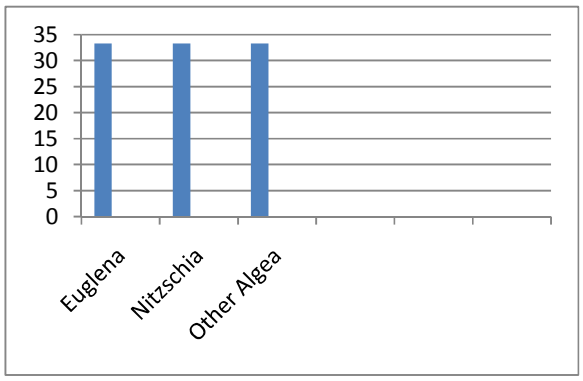

Fig 1. TheDiatoms of LamosRiver in Spring

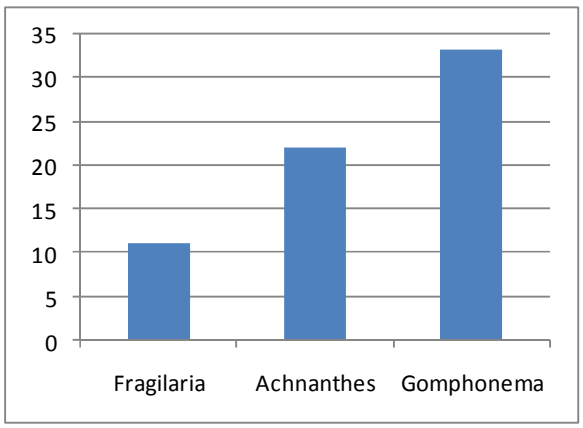

Fig 2. The Diatoms of Göksu River in Spring

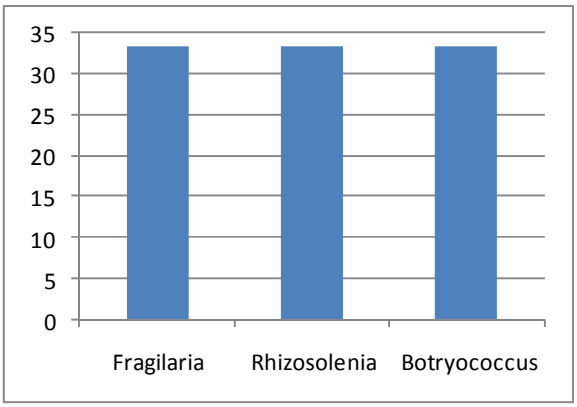

Fig3.The Diatoms of Paşasuyu Creek in Spring

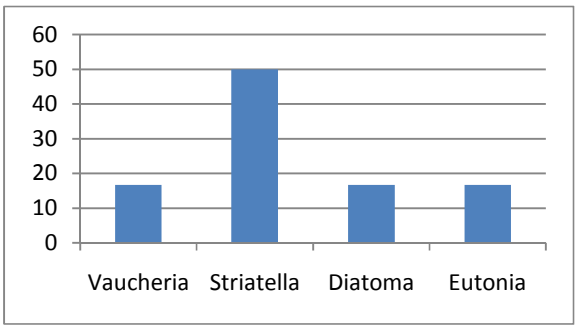

Fig4.The Diatoms of Arpaçbahşiş in Spring

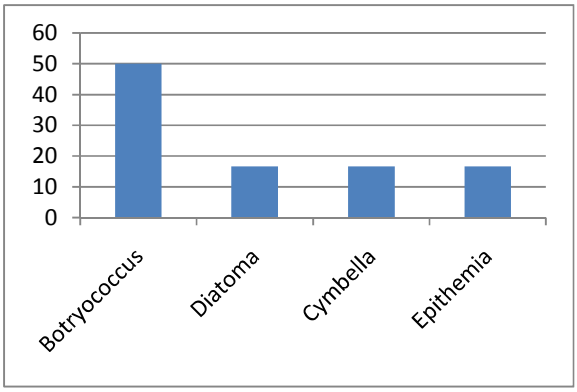

Fig5.The Diatoms of Mezitli Creek in Spring

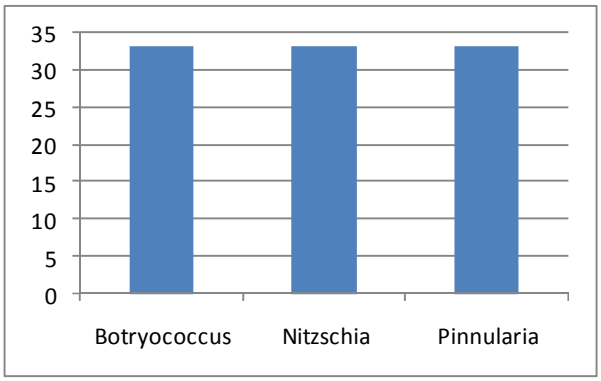

Fig6.The Diatoms of KandakCreek in Spring

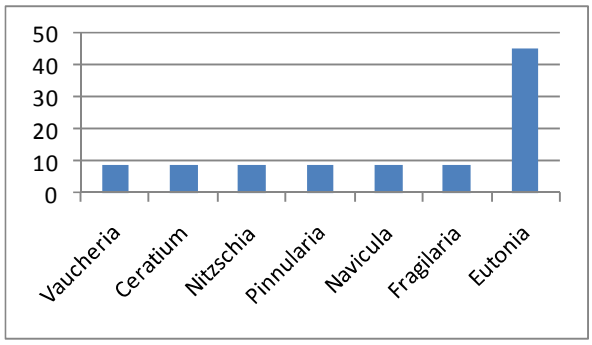

Fig 7. The Diatoms of KapızCreek in Spring

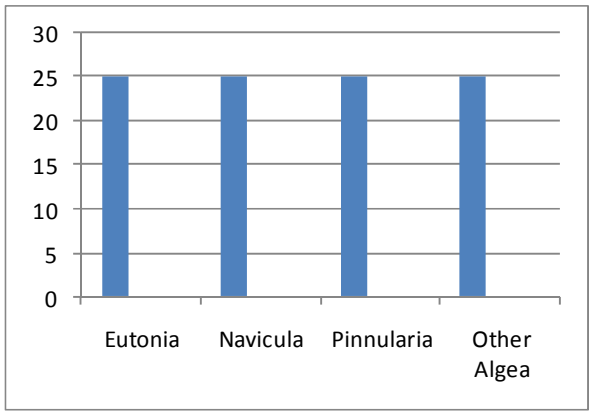

Fig 8.The Diatoms of Erdemli Creek in Spring

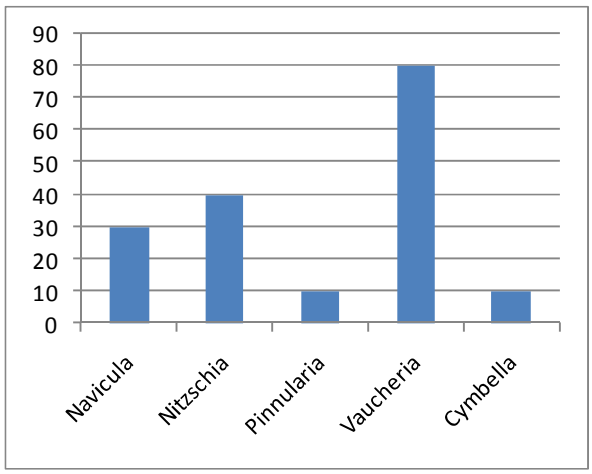

Fig 9.The Diatoms of LamosRiver in Summer

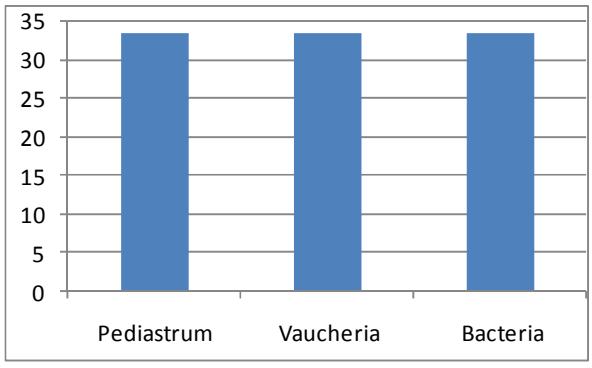

Fig 10.The Diatoms of Göksu River in Summer

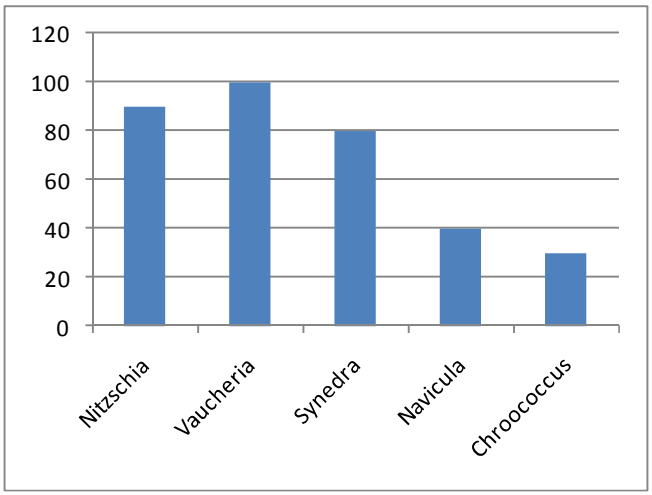

Fig 11.The Diatoms of KargıpınarıCreek in Summer

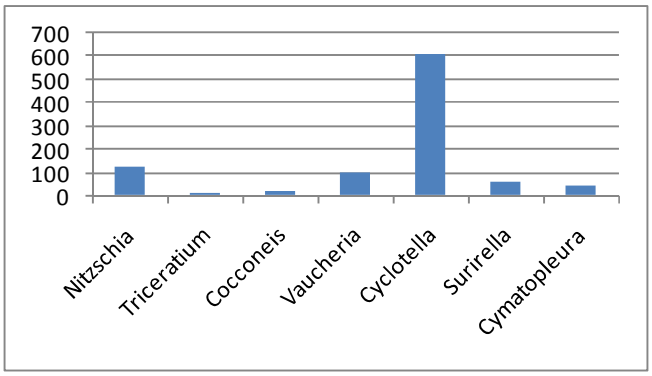

Fig 12.The Diatoms of PaşasuyuCreek in Summer

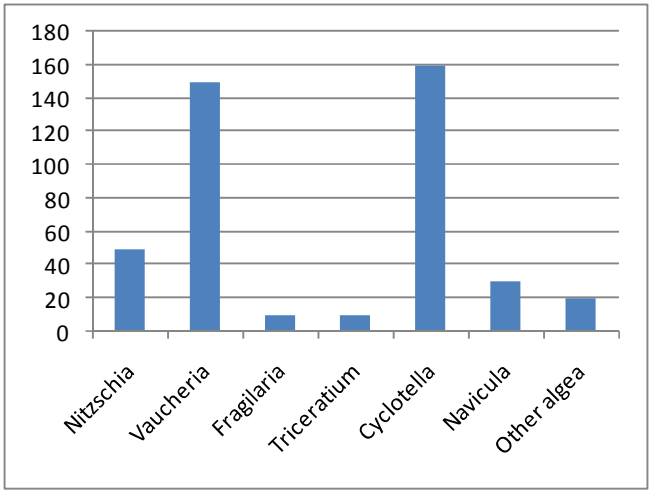

Fig 13. The Diatoms of Müftü Creek in Summer

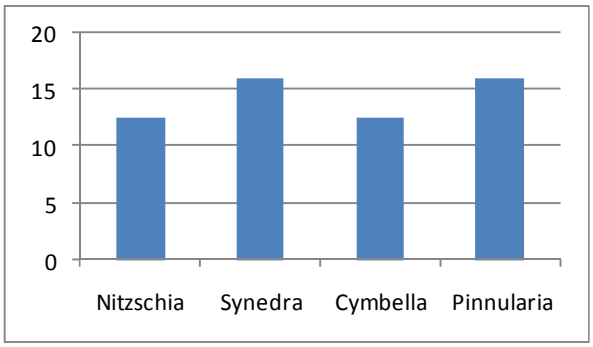

Fig 14.The Diatoms of LamosRiver in Autumn

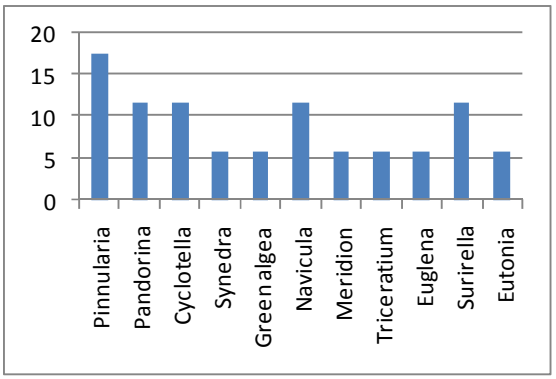

Fig18. The Diatoms of Çiftlikköy Creek in Autumn

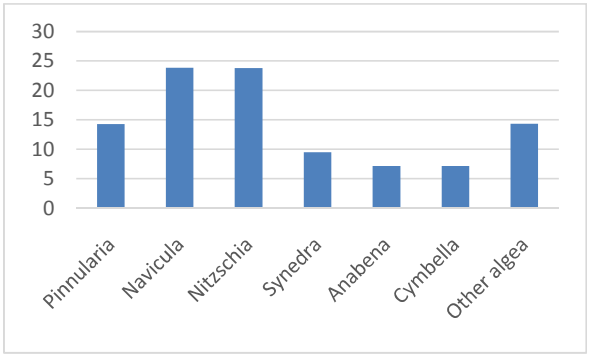

Fig 15.The Diatoms of Göksu River in Autumn

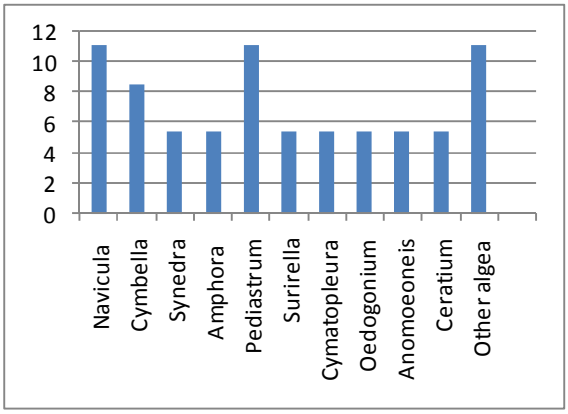

Fig 19.The Diatoms of Müftü Creek in Autumn

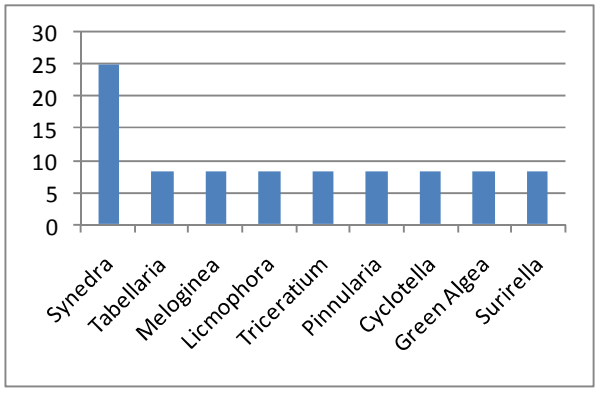

Fig 16.The Diatoms of KargıpınarıCreek in Autum

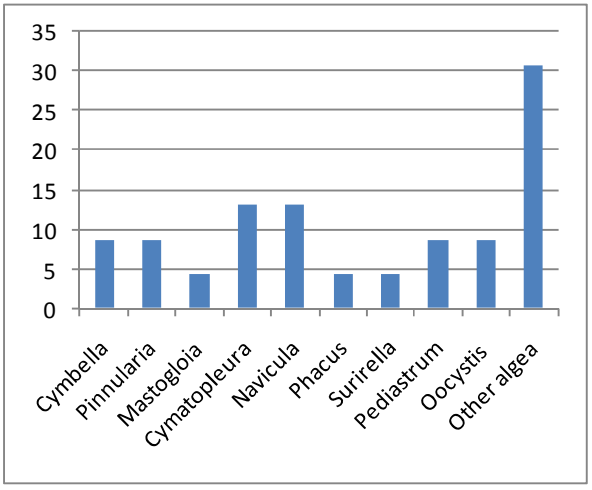

Fig 20.The Diatoms of LamosRiver in Winter

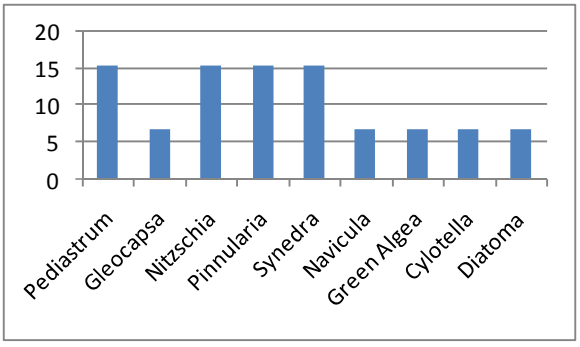

Fig 17.The Diatoms of PaşasuyuCreek in Autumn

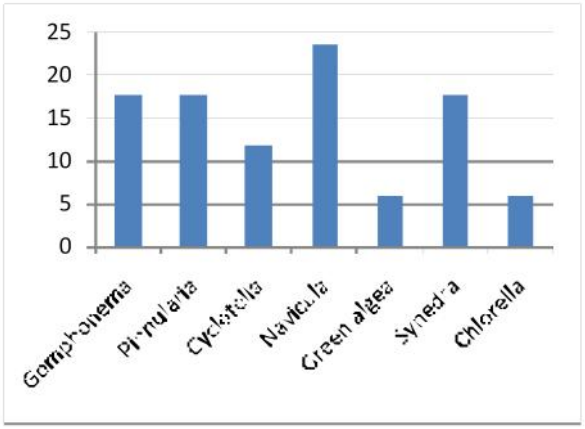

Fig 21.The Diatoms of Göksu River in Winter

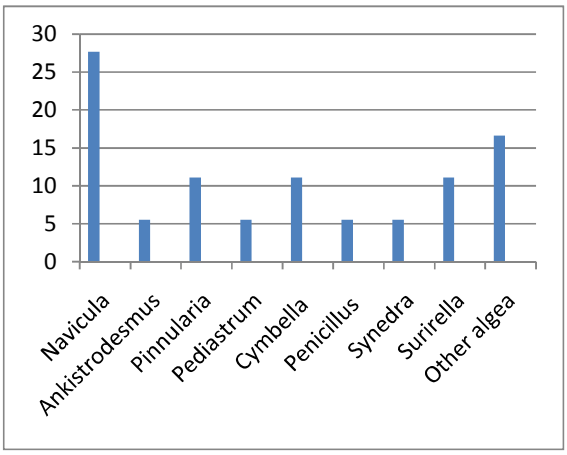

Fig24.The Diatoms of GöksunCreek in Winter

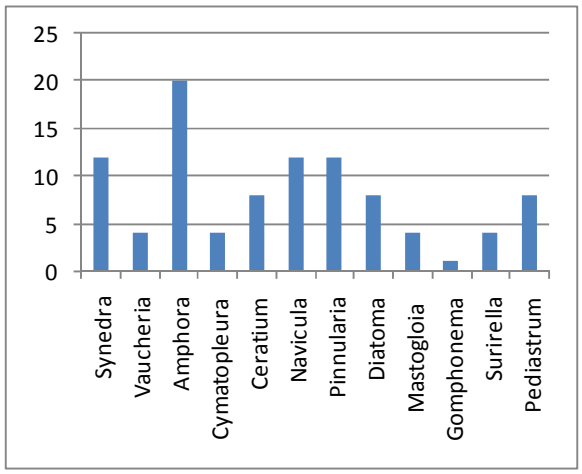

Fig 22.The Diatoms of KargıpınarıCreek in Winter

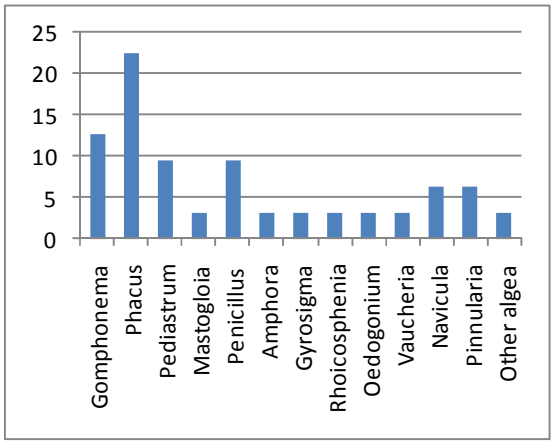

Fig25.The Diatoms of Dragon Creek in Winter

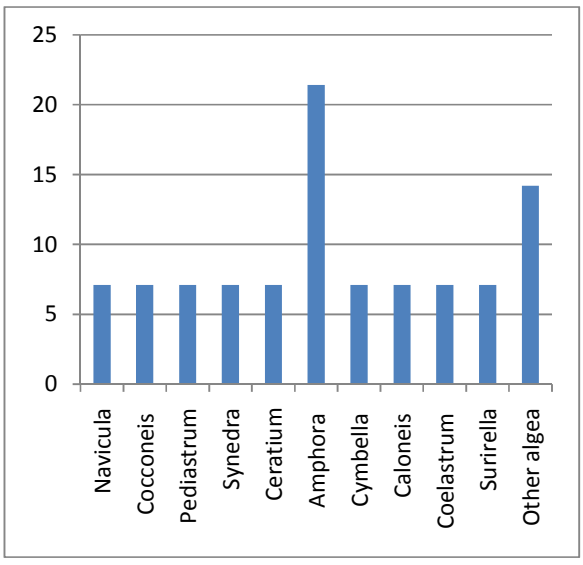

Fig 23. The Diatoms of PaşasuyuCreek in Winter

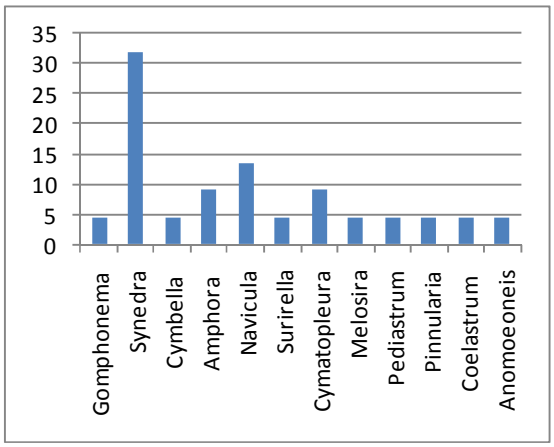

Fig26.The Diatoms of ArpaçbahşişCreek in Winter

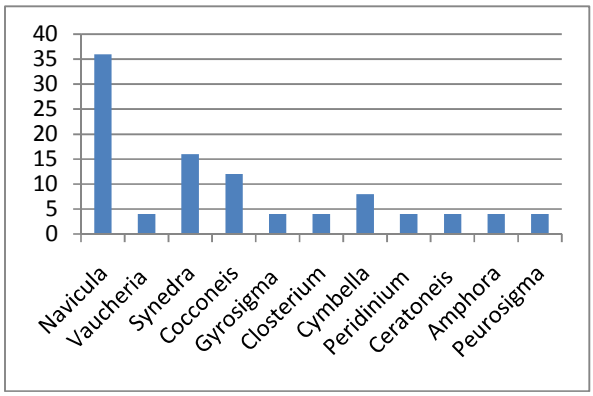

Fig27.The Diatoms of Mezitli Creek in Winter

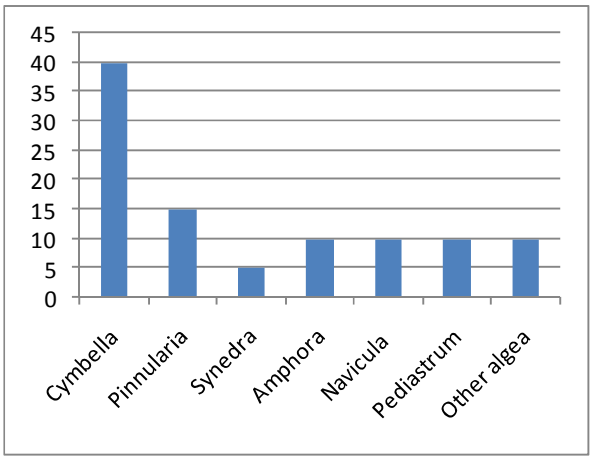

Fig30.The Diatoms of AquaparkCreek in Winter

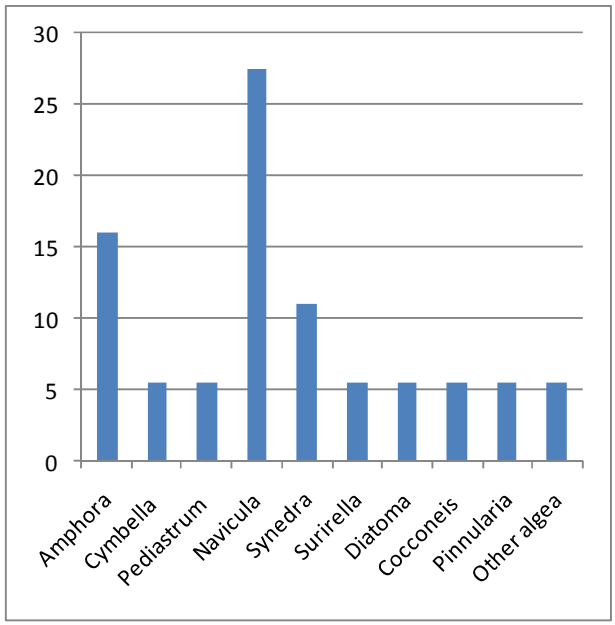

Fig28.The Diatoms of KaradedeliCreek in Winter

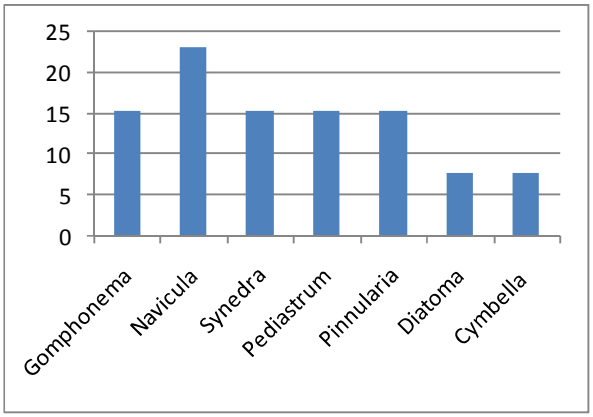

Fig 31. The Diatoms of Soğuksu in Winter

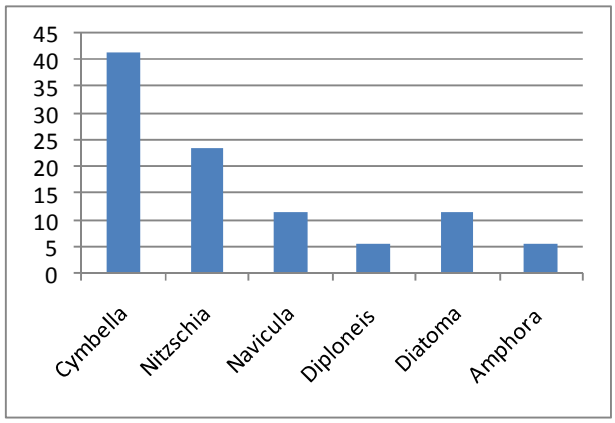

Fig29.The Diatoms of KandakCreek in Winter

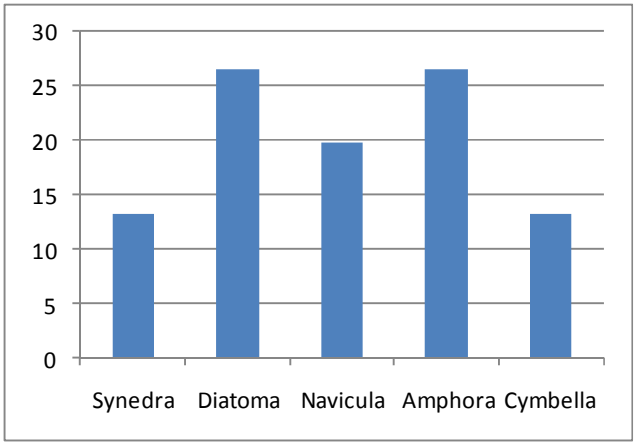

Fig32. The Diatoms of Sultansuyu in Winter

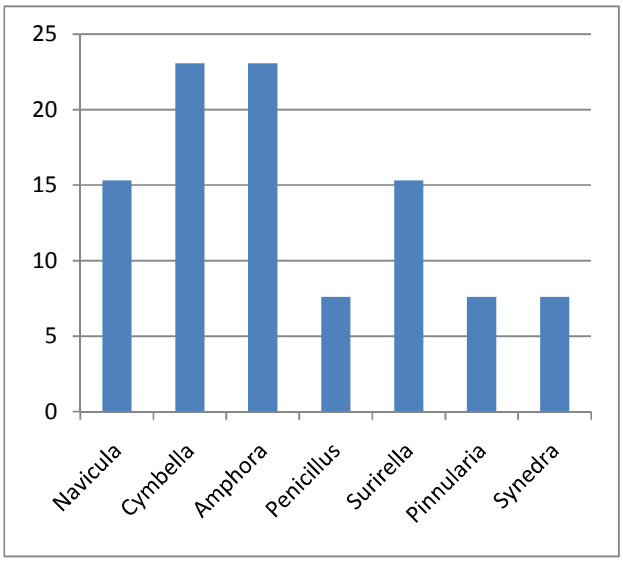

Fig 33.The Diatoms of Anamur Creek in Winter

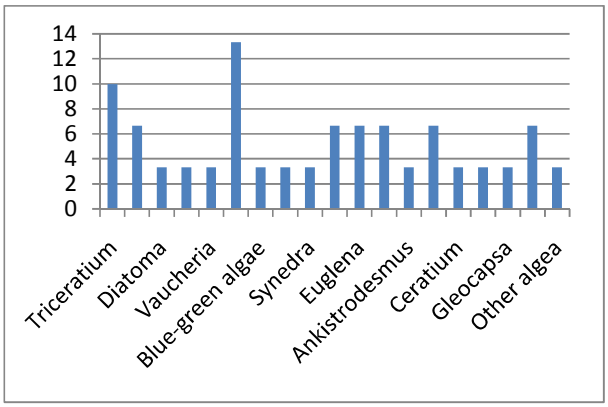

Fig 34.The Diatoms of Berdan River in Winter

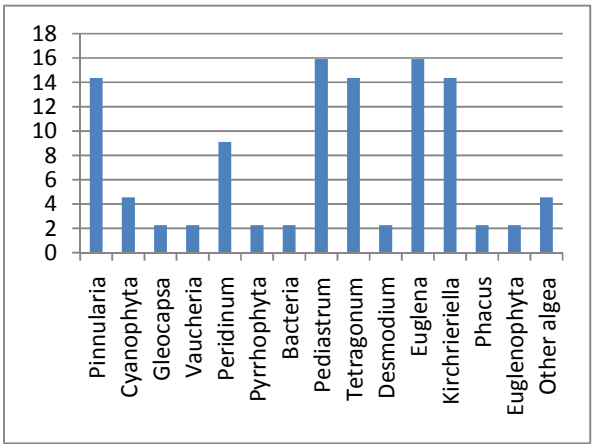

Fig 35.The Diatoms of Kuyuluk Creek in Winter