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# Planktonic Chlorophyceae from the Grand-Lahou lagoon in Côte d'Ivoire, West Africa

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## ABSTRACT
*Objective:* To study and contribute to the knowledge of phytoplankton in Grand-Lahou lagoon of Côte d'Ivoire.
*Methodology and results:* The phytoplankton samples were collected with a 20 µm mesh wide plankton net in ten stations. Observations permitted the registration of 40 specific and infraspecific taxa (varieties and forms) of Chlorophyceae divided into seven families: Scenedesmaceae (26), Hydrodictyaceae (6), Volvocaceae (3), Oocystaceae (2), Botryococcaceae (1), Gloeocystaceae (1) and Radiococcaceae (1).
*Conclusion and applications:* This study has improved the knowledge of the algae populations of the Grand-Lahou lagoon. Seventeen of these taxa have not been reported previously in Côte d'Ivoire. The knowledge of the taxonomic composition of the phytoplankton will enable better assessment of the state of pollution in the Grand-Lahou lagoon.
**Key words:** phytoplankton, Chlorophyceae, Chlorococcales, Volvocales, Grand-Lahou lagoon, Côte d'Ivoire.

## INTRODUCTION
The green algae (Chlorophyceae) compose the largest and most varied phylum of algae. They are the most closely related species to higher plants because of their similar photosynthetic pigments, storage of starch and the fine structural organization of the chloroplast (Happey-Wood, 1988). The green algae include a greater diversity of cellular organization, morphological structure and reproductive processes than those found in any other algal division (Bold et al., 1978).
The composition of some groups of Chlorophyceae (Chlorococcales, Volvocales) from continental waters in Côte d'Ivoire is not well known (Bourrelly, 1961; Da et al., 1997; Ouattara et al., 2000). The Grand-Lahou lagoon, on the other hand, has never been the subject of any detailed algological investigation. In this paper we show the results of a one year study carried out from January to December 2005 in which phytoplankton was monitored and collected at ten points. The present paper contributes to the knowledge of the taxonomic composition of the phytoplankton from Grand-Lahou lagoon, especially some planktonic Chlorophyceae (Chlorophyta), including original pictures.

## MATERIALS AND METHODS

**Study area** : The Grand-Lahou Lagoon (4°- 5°25' W , 5° 07'- 5°14' N, 190 km$^2$, mean depth of ca. 3 m) spreads about 50 km along the Gulf of Guinea coastline (Lecolle, 1971). It comprises four basins (Lae, 1982) (Figure 1). The Tadio lagoon (90 km$^2$, 2-3 m in maximum depth) is the largest one. It undergoes the influence of a small forest river (Boubo) having two floods in May-July and October-November, the former one being the most important. The Niouzoumou lagoon (15 km$^2$, 3 m in maximum depth) is a narrow basin parallel to the coastline. It is enclosed and sheltered on the upper strand of a 3,000-ha coconut agro-industrial plantation. The Mackey lagoon (28 km$^2$), the shallowest basin (2 m maximum depth) joins the Tadio and Tagba lagoons. The Tagba Lagoon (57 km$^2$) is located at the eastern extremity and has an average depth of 3 m, but its depth can reach 8 m and near the channel. It links directly with the sea by the only outlet of the complex, the Grand-Lahou channel, and receives water inputs from the Bandama River during the unique flood occurring in October-November (Durand et al., 1994).

**Collection of specimens:** The phytoplankton samples for qualitative analyses were collected with a 20 µm mesh plankton net by vertical tows in the centre of the stream at every sampling station (Figure 1). The samples were transferred into plastic vessel (40 ml) and fixed with 40 % formalin buffered with borax to a final concentration of 5 % (Throndsen, 1978).

**Identification and Taxonomy:** The qualitative phytoplankton analysis was made with an Olympus microscope, type CX 31, equipped with digital camera for photographing, measuring and recording the photographs. The taxonomic classification used in this paper is based mainly on Komárek and Fott (1983). In special cases, other authors are cited in the text. Concerning the problematic genus *Scenedesmus,* two recent papers were published (An et al., 1999 and Hegewald, 2000), which modified the traditional concept of the genus. According to these authors, *Scenedesmus* is divided in two separate genera: *Scenedesmus* and *Desmodesmus*.

**Measurement of water physico-chemical properties:** At each site, physical and chemical properties of water were recorded on monthly basis for one year from January to December 2005. Portable devices from multiparametric sounding (SET Model 351i) were used to measure the water temperature, conductivity and salinity, dissolved oxygen (YSI Model 57) and pH (Model 98158). Samples for other parameters (phosphates and nitrates) were kept in bottle and brought to laboratory for further analysis according to the methods described by Beer-Lambert (2008).

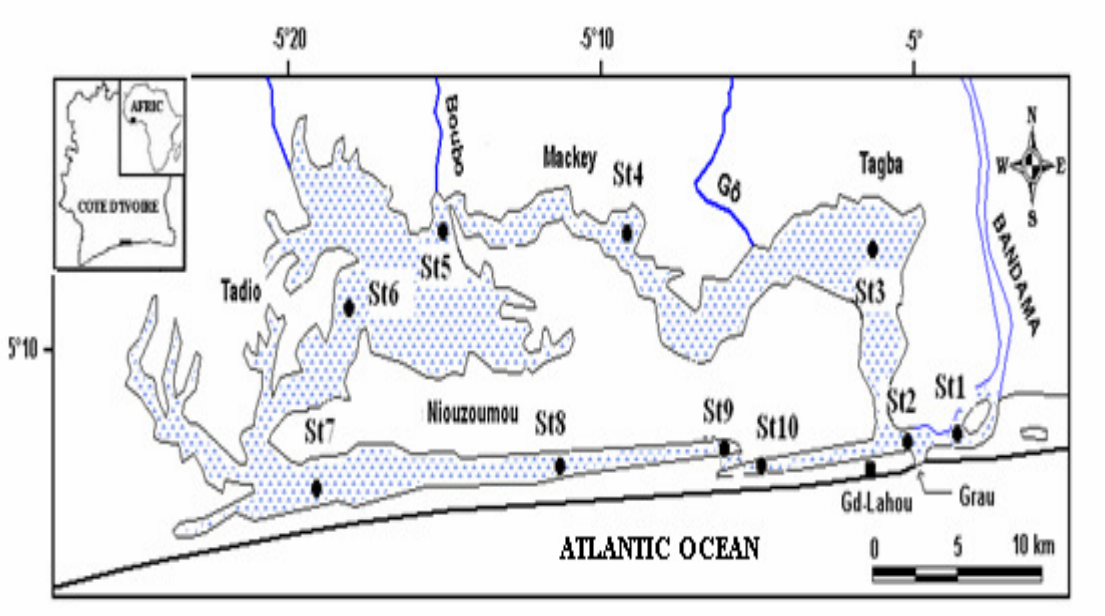



**Figure 1:** Map showing the sampling stations in the Grand-Lahou lagoon, Côte d'Ivoire.

## RESULTS AND DISCUSSION

The pH values varied between 6.63 and 9.23; surface temperature varied between 17.25 and 30.43°C and the conductivity between 0.5 and 41.64 mS $cm^{-1.}$ The surface salinity varied between 0. 25 and 26. 95 ‰. Nitrates and phosphates values varied from 0.31 to 17.94 mg $L^{-1}$ and from 0.07 mg $L^{-1}$ to 2.24 mg $L^{-1}$ respectively.

**Taxonomic remarks:** The different species observed are described alphabetically. Rule scale bars in illustrations represent 20 µm. New taxa to the algal flora of Côte d'Ivoire are designated with one asterisk (*)

**Chlorococcales Marchand orth. mut. & emend. Pascher**

**Botryococcaceae Wille**

***Dictyosphaerium pulchellum* Van Goore (figure 2):** Cells globose, 2-3 µm in diameter, with pyrenoid.

**Gloeocystaceae Kützing**

***Gloeocystis ampla* (Kützing) Rabh. (Figure 3):** Cells ovoid or subspheric, with pyrenoid, embedded in common mucilage. Dimensions: 10-15 x 7-8 µm.

**Hydrodictyaceae (S.F. Gray) Dumortier orth. mut.**

***Pediastrum duplex* Meyen var. *duplex* (figures 4-5) :** Coenobia, flat, circular, composed of 16 cells **(figure 4)** or 32 cells **(figure 5)**. Marginal cells of colonies extended into two conical blunt-tipped processes. In one case a colony of 16 or 32 cells, 50-60 µm in diameter, was observed (peripheral cells 10, 6-12 x 10, 1-11, 8 µm, inner cells 9-10 x 9-10).

***Pediastrum duplex* var. *gracillimum* W. & G.S. West (figure 6):** Colonies composed of 32 cells. Dimensions: 11, 2-16, 9 x 10, 4-12, 3 µm.

***Pediastrum simplex* Meyen var. *simplex* (figures 7-8):** Cells dimensions: 13, 7-18, 2 x 10-14 µm, horns up to 6, 7 µm long. It shows, however, a wide morphological variability: irregularly or concentric arranged cells in coenobia, with or without spaces between internal cells and different ornamented cell walls. Abnormalities in the cell and coenobia morphology were also found. In the samples were observed organisms identical with few described infraspecific taxa : var. **echinulatum* Wittrock **(figures 9-10)** and var. **sturmii* (Reinsch) Wolle **(figures 11-12),** therefore the taxonomical evaluation of these different types at infraspecific ranks was not easy because transition types were found in one and the same population.

***Sorastrum americanum* (Bohlin) Schmidle (figure 13) :** Coenobia approximately spherical and composed of eight cells which are wedge-shaped sublunate, or reniform. Cells broadly with a long spine at each end. Dimensions: 12-15 X 8-10 µm.

**Radiococcaceae Walton**

***Eutetramorus planctonica* (Korshikov) Bourrelly (figure 14):** Cells ovoid to broadly elliptical, 14-18 µm in diameter embedded in common mucilage.

**Scenedesmaceae Oltmanns**

***Actinastrum hantzschii* Lagerheim (figure 15):** Cells spindle-shaped, 8, 5-15 x 1, 6-2, 4 µm.

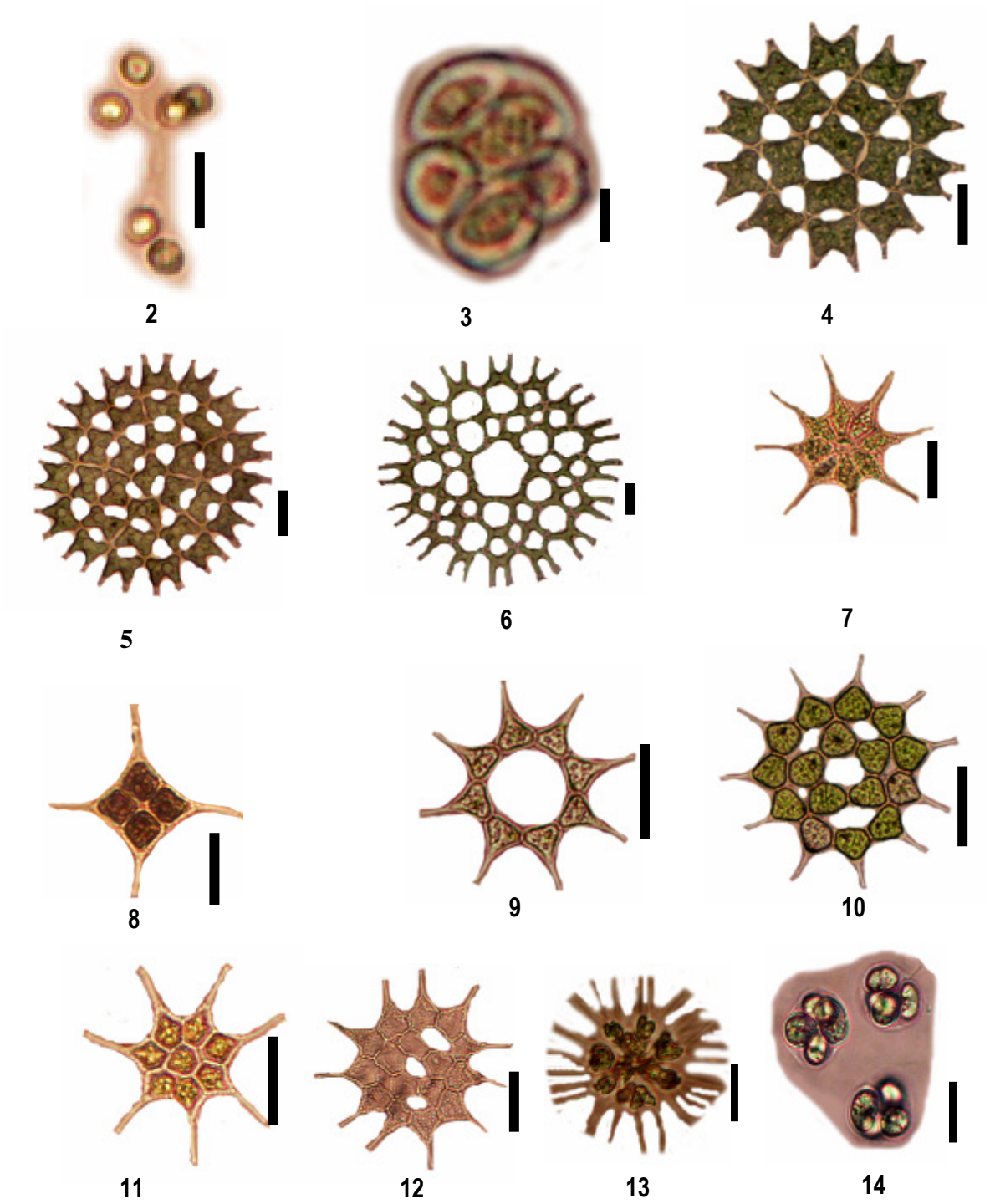
***Coelastrum astroideum* De Notaris (figure 16) :** Cells broadly pyramidal with one widely rounded process, 8-10, 5 µm in diameter.

***Coelastrum cambricum* Archer (figure 17):** Cells spherical, frequently 8 µm in diameter. Colonies compact, frequently 20-30 µm in diameter.

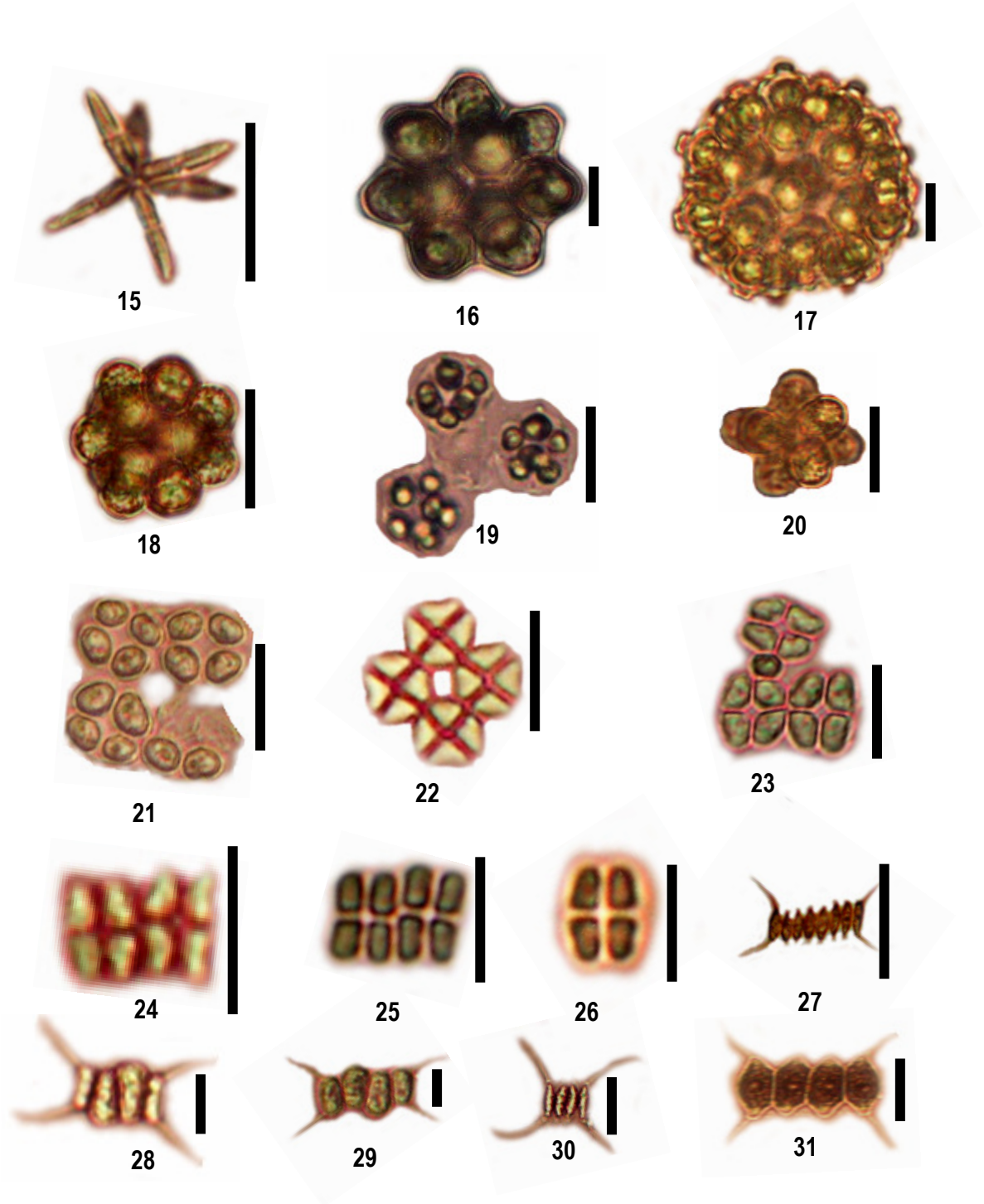
***Coelastrum indicum* Turner (figure 18):** Cells spherical or subspherical, 9-13 µm in diameter, a similar form has been found in the lake Tchad (Compère, 1976a).

***Coelastrum reticulatum* (Dang.) Senn (figure 19) :** Cells spherical ; each cell with five to seven connecting processes, but joint to a neighbouring cell by one, less frequently two processes ; cell diameter variable, 4-6 µm.

***Coelastrum sphaericum* (Nägeli) Korshikov (figure 20):** Cells spherical, 18-25 µm in diameter.




**Figures 2 – 14:** *Dictyosphaerium pulchellum* Van Goore (figure 2), *Gloeocystis ampla* (Kützing) Rabh. (figure 3), *Pediastrum duplex* Meyen var. *duplex* (figures 4-5), *Pediastrum duplex* var. *gracillimum* W. & G.S. West (figure 6), *Pediastrum simplex* var. *echinulatum* Wittrock (figures 7-8), *Pediastrum simplex* Meyen var. *simplex* (figures 9-10), Pediastrum *simplex* var. *sturmii* (Reinsch) Wolle (figures 11-12), *Sorastrum americanum* (Bohlin) Schmidle (figure 13), *Eutetramorus planctonica* (Korshikov) Bourrelly (figure 14).




**Figures 15 – 31:** *Actinastrum hantzschii* Lagerheim (figure 15), *Coelastrum astroideum* De Notaris (figure 16), *Coelastrum cambricum* Archer (figure 17), *Coelastrum indicum* Turner (figure 18), Coelastrum *recticulatum* (Dang.) Senn. (figure 19), *Coelastrum sphaericum* (Nägeli) Korshikov (figure 20), *Crucigenia quadrata* Morren (figure 21), *Crucigenia tetrapedia* (Kirchner) W. & G. S. West (figure 22), *Crucigeniella apiculata* Morren (figure 23), *Crucigeniella crucifera* (Wolle) Komárek (figure 24), *Crucigeniella neglecta* (Fott & Ettl) Komárek (figure 25), *Crucigeniella rectangularis* (Nägeli) Komárek (figure 26), *Desmodesmus armatus* (Chodat) Hegewald (figure 27),

*Desmodesmus intermedius* (Chodat) Hegewald (figures 28-29), *Desmodesmus opoliensis* var. *mononensis* (Chodat) Hegewald (figure 30), *Desmodesmus protuberans* Fritsch & Rich) Hegewald (figure 31).

***Crucigenia quadrata* Morren (figure 21):** Cells elliptical, 6 x 5 µm; arranged in four-celled coenobia ; cells frequently four. Colonies consisting of four cells arranged around a rhomboid central space.

***Crucigenia tetrapedia* (Kirchner) W. & G. S. West (figure 22):** Cells triangular, cruciately arranged in four-celled coenobia ; cells frequently four, colonies 10 µm in diameter.

***Crucigeniella apiculata* Morren (figure 23) :** Cells oblong, straight or slightly reniform, 6-8 x 4-5 µm. Colonies consisting of four cells arranged around a rhomboid central space.

***Crucigeniella crucifera* (Wolle) Komárek (figure 24) :** Cells reniform, 5-5, 2 x 3-3, 4 µm. Coenobia, rhomboedric, composed of 8 cells.

***Crucigeniella neglecta* (Fott & Ettl) Komárek (figure 25):** This species is near to *Crucigenia rectangularis* but differs by its more or less right cells. Dimensions: 5-7 x 2, 5-3 µm.

***Crucigeniella rectangularis* (Nägeli) Komárek (figure 26):** Colonies frequently composed of four cells. Cells dimensions: 5-8 x 3-6 µm.

***Desmodesmus armatus* (Chodat) Hegewald (figure 27):** Cells ellipsoid, linear, 7-8 x 3-4 µm ; marginal cells with a long spine at each end ; the other apices with one short tooth.

***Desmodesmus intermedius* (Chodat) Hegewald (figures 28-29):** Cells ovoid, 6-12 x 3-5 µm, marginal cells with a long spine at each end.

***Desmodesmus opoliensis* var. *mononensis* (Chodat) Hegewald (figure 30):** Cells, spindle-shaped, truncated ends, joined for 1/2 -1/3 of the total length into four-celled coenobia. Marginal cells with a long spine at each end. Dimensions: 7-14 x 3-4 µm.

***Desmodesmus protuberans* (Fritsch & Rich) Hegewald (figure 31):** Cells cylindrical or spindle-shaped, 12-16 x 5-7 µm, truncated ends, joined for 2/3 of the total length into four-celled coenobia. Marginal cells with a long spine at each end.

***Scenedesmus acuminatus* (Lagerheim) Chodat (figure 32):** Cells spindle-shaped, 13-18, 6 x 3, 2-4, 9 µm, straight or slightly and often irregularly and curved, very variable in shape. Marginal cells are curved, one of the marginal cells having been destroyed.

***Scenedesmus bernardii* G. M. Smith (figure 33):** Cells crescent-shaped, 15-23, 2 x 3-5, 7 µm.

***Scenedesmus calptratus* Comas (figure 34):** Colonies frequently composed of four cells; cells ellipsoidal ; rounded at the ends. Dimensions: 14-22 x 4-6 µm.

***Scenedesmus disciformis* (Chodat) Fott & Komárek (figure 35):** Cells ovoid-ellipsoidal, 7-12 x 4-6 µm.

***Scenedesmus incrassatulus* Bohlin (figure 36):** Cells ellipsoidal, 12-13 x 3-7 µm, with a somewhat thickened wall at the ends.

***Scenedesmus obtusus* var. *obtusus* fo. *granulatus* (Schmidle) Compère (figure 37):** This species differs from *Scenedesmus obtusus* by its wall covered by small granules. Dimensions: 7- 8, 3 x 3-6 µm.

***Scenedesmus quadricauda* var. *quadricauda* (Turpin) Brébisson (figure 38):** Coenobia of four cells; cells linearly arranged; 6-25 x 3-10 µm; marginal cells with a long spine at each end.

***Scenedesmus quadricauda* var. *longispina* fo. *granulatus* Uherkovich (figure 39):** Coenobia of four cells ; cells cylindrical, linear, 12 x 18 µm. Marginal cells with a long spine at each end, the other apices with one short tooth.

***Scenedesmus quadricauda* var. *quadrispina* (Chodat) Smith fo. *quadrispina* (figure 40):** Cells linear, are blunt with subacute ends. Our materiel differs from typical species, by the presence of small spines on the outer margin of the outer cells. Dimensions: 12, 5-15, 2 x 6, 5-9, 0 µm.

***Tetrastrum komarekii* Hindák (figure 41):** Cœnobia circular, composed of 4 small cells, 3, 8-4 µm in diameter.

**Oocystaceae Nägeli**

***Keratococcus lunulatus* Hindák (figure 42):** Cells crescent-shaped, 15-25 x 4-7µm.

***Selenastrum bibraianus* Reinsch (figure 43):** Cells arcuate, approximately 20-35 x 3, 4-6, 1 joining together by the convex surface in rather large colonies.

**Volvocales Ehrenberg**

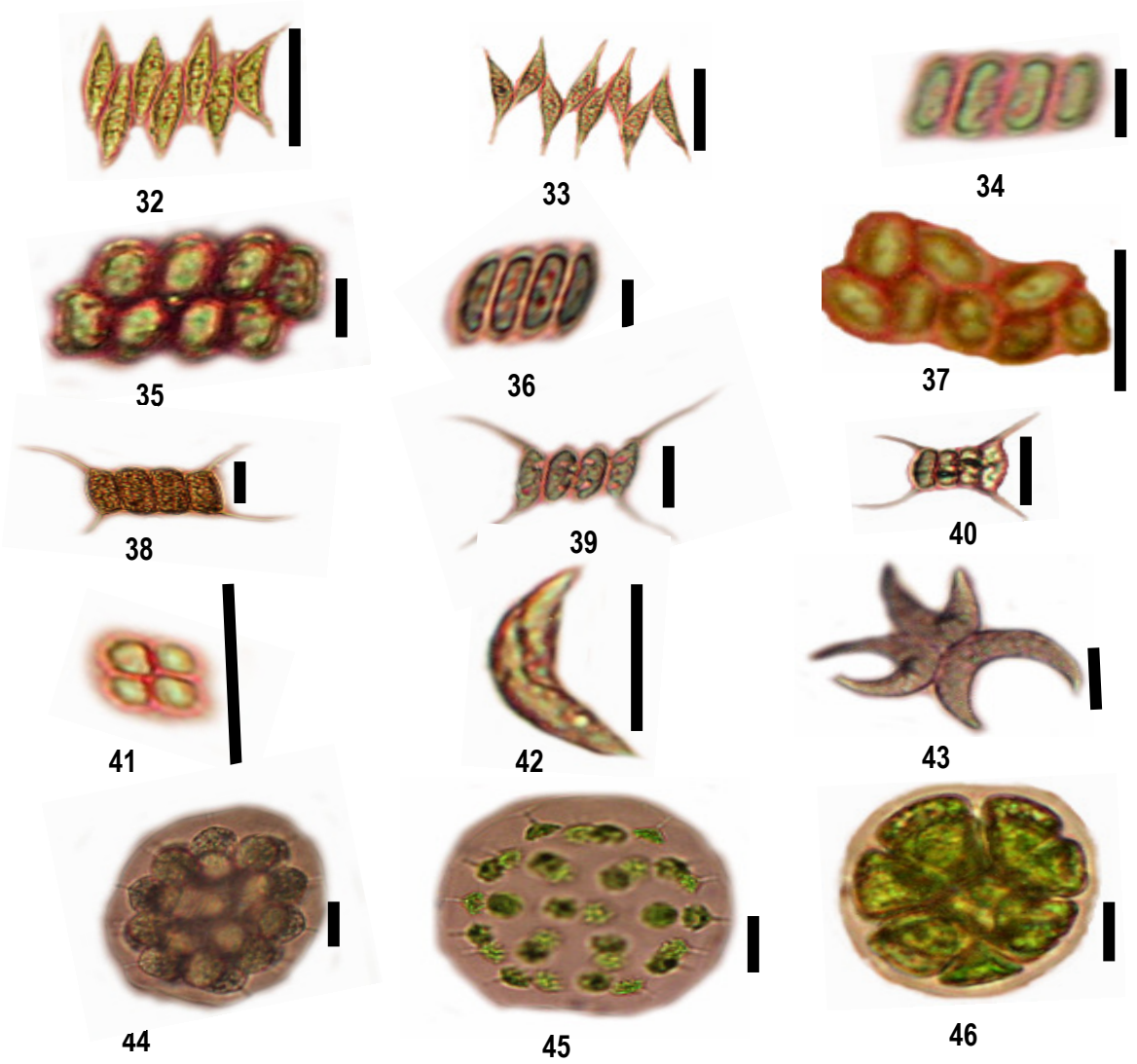
***Eudorina elegans* Ehrenberg (figure 44):** Ellipsoidal colonies, 65-85 µm in diameter. Cells globose, 13-18 µm in diameter, embedded in common mucilage.

***Eudorina unicocca* G. Smith (figure 45):** Ellipsoidal colonies, 56-80 µm in diameter, composed of 32 globose or pear-shaped cells, 10-15 x 5-7 µm, a well-defined envelope of mucilage surrounding the whole.

***Pandorina morum* (Müller) Bory (figure 46):** Spherical colonies composed of 16 pyriform cells, which are closely packed together with broadly ends outwards, a well-defined envelope of mucilage surrounding the whole, 37-53 x 33-35 µm.

## CONCLUSION

A total of 40 taxa belonging to 7 taxonomic families (Botryococcaceae, Gloeocystaceae, Hydrodictyaceae, Oocystaceae, Scenedesmaceae, Radiococcaceae and Volvocaceae) were determined in this research study. Coelastrum astroideum De Notaris, Crucigenia quadrata Morren, Crucigeniella apiculata Morren, Crucigeniella neglecta (Fott & Ettl) Komárek, Desmodesmus opoliensis var. mononensis (Chodat) Hegewald, Eudorina unicocca G. Smith, Eutetramorus planctonica (Korshikov) Bourrelly, Gloeocystis ampla (Kützing) Rabh., Keratococcus lunulatus Hindák, Pediastrum simplex var. echinulatum Wittrock, Pediastrum simplex var. sturmii (Reinsch) Wolle, Scenedesmus incrassatulus Bohlin, Scenedesmus obtusus var. obtusus fo. granulatus (Schmidle) Compère, Scenedesmus quadricauda var. longispina fo. granulatus Uherkovich, Scenedesmus quadricauda var. quadrispina (Chodat) Smith fo. quadrispina, Sorastrum americanum (Bohlin) Schmidle, Tetrastrum komarekii Hindák, are reported for the first time in this country. The best represented genus was Scenedesmus, with 9 taxa. According to Hutchinson (1967), Moss (1972, 1973) and Mason (1991), Pediastrum duplex Meyen, Scenedesmus quadricauda (Turpin), Eudorina elegans Ehrenberg and Pandorina morum (Müller) are good indicators of eutrophic conditions.



**Figures 32 – 46:** *Scenedesmus acuminatus* (Lagerheim) Chodat (figure 32), *Scenedesmus bernardii* G. M. Smith (figure 33), *Scenedesmus calptratus* Comas (figure 34), *Scenedesmus disciformis* (Chodat) Fott & Komárek (figure 35), *Scenedesmus incrassatulus* Bohlin (figure 36), *Scenedesmus obtusus* var. *obtusus* fo. *granulatus* (Schmidle) Compère (figure 37), *Scenedesmus quadricauda* var. *quadricauda* (Turpin) Brébisson (figure 38), *Scenedesmus quadricauda* var. *longispina* fo. *granulatus* Uherkovich (figure 39), *Scenedesmus quadricauda* var. *quadrispina* (Chodat) Smith fo. *quadrispina* (figure 40), *Tetrastrum komarekii* Hindák (figure 41), *Keratococcus lunulatus* Hindák (figure 42), *Selenastrum bibraianus* Reinsch (figure 43), *Eudorina elegans* Ehrenberg (figure 44), *Eudorina unicocca* G. Smith (figure 45), *Pandorina morum* (Müller) Bory (figure 46).

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