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Cyanobacteria from a shallow Reservoir in Côte d'Ivoire

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Abstract

This paper is the result of the study of the Cyanobacteria flora from the raw potable water reservoir of Adzopé, located in South-Est of Côte d'Ivoire. The samples were collected monthly from January to December 2005. The species composition of the assemblage was compiled, accompanied by illustrations. Thirty three species of cyanobacteria were identified in the temporal survey. Oscillatoriales was the order with the highest species richness (56.25% of the total of the identified species), followed by Chroococcales (43.75%). Nine species and subspecies were recorded for the first time in Côte d'Ivoire. Highest species richness was observed on substrates. No spatial variations in the taxonomic composition of the populations of Cyanobacteria were found. Variations were encountered in the seasonal analysis. The spectrum of the meaningful species points out that a very low number of species contributed significantly to the Cyanobacteria occurrence. Among them, *Microcystis aeruginosa* and *Planktothrix rubescens* were well represented during dry season and rainy seasons respectively.

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Introduction

Cyanobacteria are probably the oldest organisms with oxyphototrophic metabolism. In spite of their long existence, they have not lost their vitality, and still are able to colonize all possible biotope (Komarek and Anagnostidis, 1999). Globally, they are the primitive photosynthetic microorganisms which have tremendous potential in environmental management, as soil conditioners, bio-fertilizer, bio-monitors of soil fertility, water quality, ameliorators agents, feed for animals and protein supplements and rehabilitation of degraded ecosystems through bio absorption of metals (Whitton and Potts, 2000). They also play a crucial role in the bio-geochemical cycles of nitrogen, carbon, and oxygen (Naveen *et al.*, 2014). Their old origin, variation, stability of distinguishable types, diversification abilities, adaptation to various ecological situations, and structural and metabolic specifities, make Cyanobacteria one of the most fascinating groups of organisms (Komarek and Anagnostidis, 1999).

Despite of their importance and their worldwide distribution, Cyanobacteria communities in freshwater is relatively poorly known in Côte d'Ivoire. The first references of them from this country date back to the middle of last century (Bourrelly (1961) and Uherkovich and Rai (1977)). Recent studies, done by Da *et al.* (1999) and Ouattara *et al.* (2000) shown that the diversity of Cyanobacteria from Côte d'Ivoire is considerably larger than is apparent from the literature. It is clear that new data on Cyanobacteria from different natural habitats across Côte d'Ivoire are urgently required to gain a better understanding of their diversity.

The aims of this study are : 1- to provide a taxonomic inventory of the Adzopé reservoir Cyanobacteria; 2- to give the floristic composition of the Cyanobacteria community occurring in the reservoir.

Material and methods

Description of study area

The reservoir as shown in Figure 1, located between 6°10'52" - 6°12'15" N and 3°85'65" - 3°86'73" W, lies in an urban area of Adzopé's city, in the south-east of Côte d'Ivoire that belongs to the subequatorial zone (Iltis and Lévêque, 1982). It has a surface area of 61.44 ha. The reservoir has a maximum depth of 7 m and a length of about 2 km. It has no permanent inflowing streams, but there is an overflow channel at its southern end. The sources of water inputs are seasonal, usually being direct precipitation in the form of rainfall.

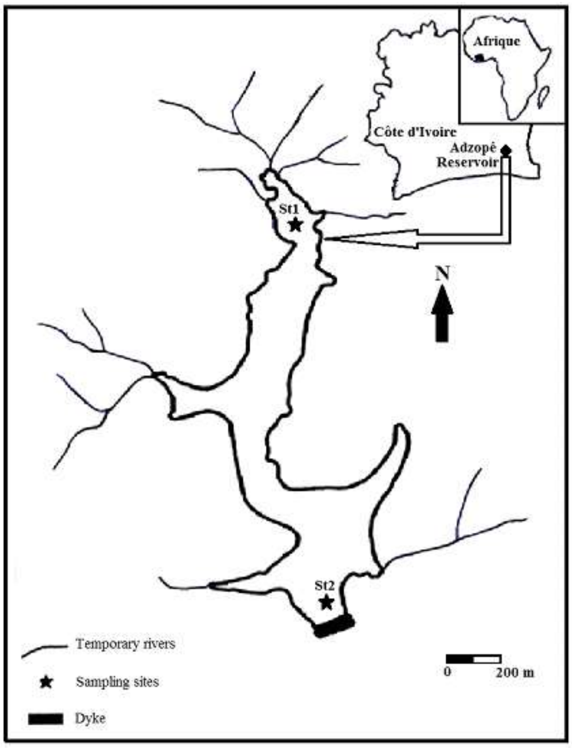

Fig. 1. Localization of the Adzopé Reservoir with sampling sites.

The area has four seasons as shown in Figure 2: the

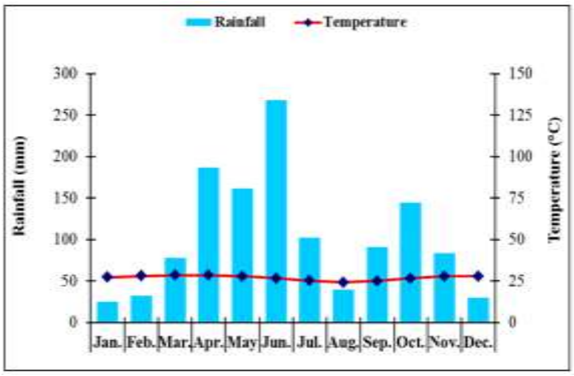

Fig. 2. Climate graph of Adzopé area.

long dry season (December-February), the long rainy season (March-July); the short dry season (August) and the short rainy season (September-November). The reservoir was built in 1977 for water supplementation. Two sampling stations (St1 and St2) were sampled according to the longitudinal gradient as shown in Figure 1.

Physicochemical parameters

Some physicochemical measurements were made in the field immediately after each sample was collected. The Conductimeter Aqualitic CD24 was used to assess water temperature and conductivity. Dissolved oxygen was measured with the Oxymeter Aqualitic OX24, and pH with the pHmeter Aqualitic, pH24. For nutrients (orthophosphates and nitrates), subsamples of 30 ml were collected and refrigerated for later analysis according to the standard methods AFNOR T90-23 and T90-110. The water transparency (Z_{SD}) was measured *in situ*, using a white Secchi disk.

Biological parameters

Algae communities were assessed both by sampling natural (stones and leaves of *Nymphaea lotus*) and artificial (glass slides and pieces of woods) substrates located at well-illuminated places. Algae were removed monthly by scraping the substrates with razor blades. Others samples were collected with 20 µm mesh plankton net at surface level.

The Cyanobacteria community was immediately examined in the laboratory without any fixation. After this, samples were preserved with Lugols Iodine solution. Observations were carried out using an Olympus BX40 microscope, equipped with a Canon camera. The identification and worldwide distribution of the species were based on the research done by Desikachary (1959), Komárek & Anagnostidis (1999 and 2005), Bourrelly (1961), Compère (1974 and 1986), McGregor*et al.* (2007), Nguyen *et al.* (2014). The taxa indicated by an asterisk are reported for the first time in Côte d'Ivoire.

In average, 50 organisms were used for measurements. The frequency of each species present was determined according to Dajoz (2000). Three frequency groups were distinguished according to value of F : Common species (1) : F > 50% ; occasional species (2) : 25% < F < 50 % ; rare species (3) : F < 25%.

Results

Physicochemical parameters

The physicochemical parameters at different sampling stations throughout the seasons are summarized in Table 1.

The reservoir water temperature fluctuated between 23.3 °C during the short dry season and 30.13 °C during the short rainy season. The conductivity exhibited a low fluctuation throughout the seasons. It

Table 1. Physicochemical parameters during the study.

		Temperature (°C)	Conductivity (µS.cm^{-1})	Dissolved oxygen (mg.L^{-1})	pH	Transparency (cm)	Nitrates (mg.L^{-1})	Orthophosphates (mg.L^{-1})
St1	LDS	27.66	170.4	3.31	8.21	60	0.8	0.17
	LRS	26.4	171	3.61	7.2	35,69	0.4	-
	SDS	23.3	182.1	2.17	7.4	80	0.6	0.15
	SRS	29.31	181.44	3.09	7.39	42.33	-	0.04
St2	LDS	29.76	190.44	1.99	802	53.33	2.54	0.28
	LRS	27.9	164.78	4.374	7.56	40.8	0.40	-
	SDS	25.6	183.6	2.02	6.1	62	1.1	1.68
	SRS	30.13	176	3.2	7.56	51.34	0.5	0.11

-Values below the limit of detection

values varied from 190.44 µS.cm^{-1} in long dry season to 164.78 µS.cm^{-1} during long rainy season. The lowest average value of dissolved oxygen (1.99 mg.L^{-1}) was measured during the long dry season, then the highest (4.37 mg.L^{-1}) was in the long dry season. The measured pH varied around the neutral value 7. The lowest average values of pH were obtained during short dry season. The water transparency was essentially low (Z_{SD} min = 35.69 cm, Z_{SD} max = 80 cm), probably reflecting the high turbidity of the lake. The highest water transparency values were measured during the short dry season. The Reservoir is characterized by high concentrations of nitrate and orthophosphates. The maximum concentration of nitrates (NO_3^-) and orthophosphates (PO_4^{3-}) values determined were 2.54 mg.L^{-1} and 1.68 mg.L^{-1}, respectively. The minimum values of these parameters were below the limit of detection.

Taxonomic part

Phylum: Cyanobacteria

Class: Cyanophyceae

Order: Chroococcales

Family: Chamaesiphonaceae Borzi 1882

Genus: *Geitleribactron* Komárek 1975

****Geitleribactron periphyticum*** Komárek 1975 (Figure 3.a).

Cells straight or slightly arcuate, cylindrical, 2-3 µm wide, 5-8 µm long, slightly attenuate at the base with mucilaginous pads, rounded at the ends; Benthic, epipelic, epilithic, epiphytic and epizoic; Distribution: St1 and St2 ; Subcosmoplitan.

Family: Synechococcaceae Komárek and Anagnostidis 1995.

Genus: *Aphanothece* Nägeli 1849.

****Aphanothece stagnina*** (Sprengel) A.Braun in Rabenhorst 1863 (Figure 3.b).

Colonial, cells oval to cylindrical with rounded ends, 4-7 µm long, 2-4 µm wide, scarcely arranged through the whole mucilaginous colony ; Benthic, epipelic, epilithic and epiphytic; Distribution: St1 and St2; Temperate and tropical zones.

***Aphanothece* sp.** (Figure 3.c).

Colonial, cells oval to widely cylindrical with rounded ends, 3-6 µm long, 2-3 µm wide, scarcely arranged through the whole colony; Planktic; Distribution: St1 and St2.

Family: Chroococcaceae Nägeli 1849

Genus: *Chroococcus* Nägeli 1849

Chroococcus dispersus (Keissler) Lemmermann 1904 (Figure 3.d).

Colonies with sparsely or densely arranged cells, cells spherical or hemispherical, 3-5 µm in diameter without gas vesicles; Planktic, epipelic, epilithic and epiphytic; Distribution: St2; Cosmopolitan.

Chroococcus minutus (Kützing) Nägeli 1849 (Figure 3.e).

Solitary or in few-celled colonies with 2-4 cells. Cells spherical or oval, 5-7 µm in diameter, without gas vesicles; Planktic, tychoplanktic; Distribution: St1 and St2; Cosmopolitan.

Chroococcus turgidus (Kützing) Nägeli 1849 (Figure 4.a).

Colonies with 2-8 cells, common mucilage around colonies, cells spherical or widely oval (before division), or hemispherical, 12-15 µm in diameter; Planktic, epipelic; Distribution: St2; Cosmopolitan.

Family: Microcystaceae Elenkin 1933

Genus: *Microcystis* Kützing ex Lemmermann 1907

Microcystis aeruginosa **(**Kützing) Kützing 1846 (Figure 4.b & c).

Colonies enveloped by diffluent and indistinct slime, with densely arranged cells, more or less spherical or elongate, cells spherical, 5-8 µm in diameter, with numerous gas vesicles; Planktic, epilithic, epiphytic; Distribution: St1 and St2; Cosmopolitan.

Microcystis novacekii (Komárek) Compère 1974 (Figure 4.d).

Colonies irregularly spherical or slyghtly elongate,

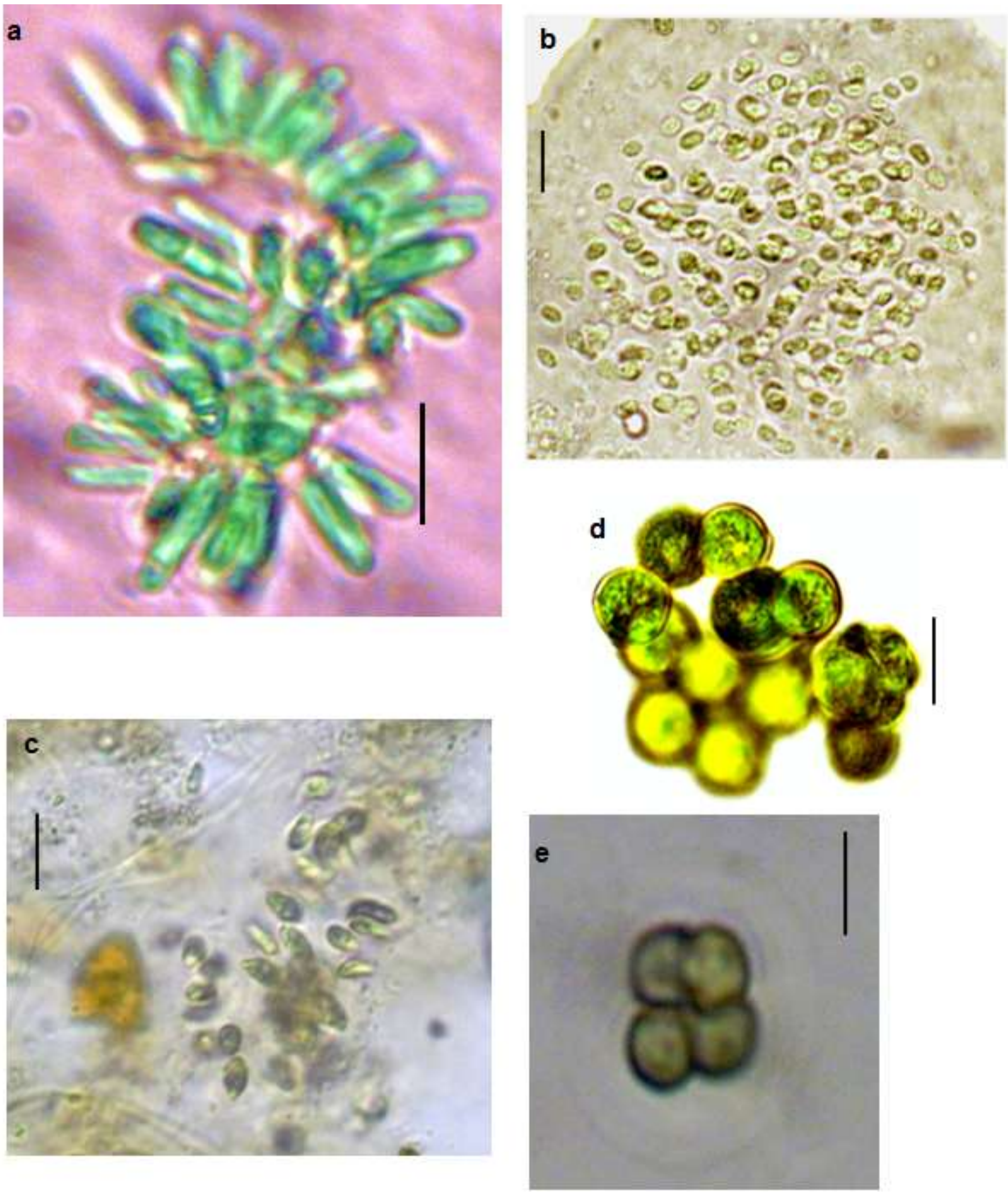

Figure3.a-*Geitleribactron periphyticum,* b-*Aphanothece stagnina*, c-*Aphanothece* sp., d-*Chroococcus dispersus,* e-*Chroococcus minutus* (Scale bar =10µm)

without holes enveloped by diffluent slime with smooth, delimited mucilage, cells spherical, 3-6 µm in diameter with numerous gas vesicles; Planktic, epilithic, epiphytic; Distribution: St1 and St2; Cosmopolitan.

***Microcystis* sp.** (Figure 4.e).

Colonies spherical or slyghtly elongate enveloped by diffluent and indistinct slime with smooth, delimited mucilage, cells spherical, 8-10 µm in diameter vith numerous gas vesicles; Epilithic, epiphytic; Distribution: St1 and St2.

Family: Merismopediaceae Elenkin 1933

Genus: *Merismopedia* Meyen 1839

Merismopedia elegans A.Braun in Kützing 1849 (Figure 4.f).

Unicellular-colonial, mucilage more or less firm, cell widely oval or elliptic, 5-8 µm long, 4-6 µm wide,

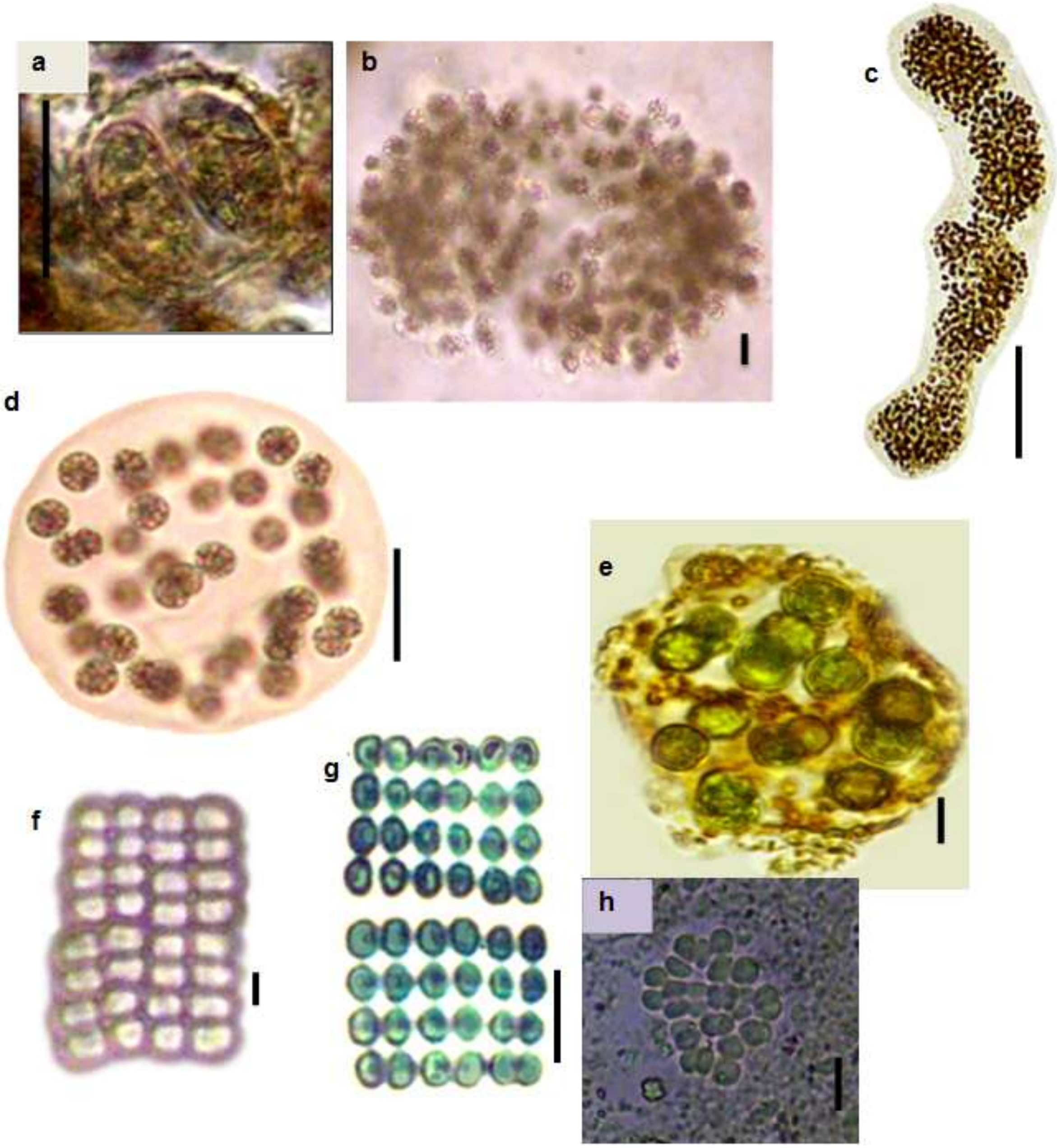

Figure 4.a-*Chroococcus turgidus,* b & c-*Microcystis aeruginosa,* d-*Microcystis novacekii,* e- *Microcystis* sp., f- *Merismopedia elegans,* g-*Merismopedia punctata,* h- *Synechocystis* sp. (Scale bar =10 µm)

more or less densely arranged in perpendicular rows; Epilithic; Distribution: St2; Cosmopolitan.

Merismopedia punctata Meyen 1839 (Figure 4.g).
Colonial tabular, mucilage more or less firm, cells more or less loosely arranged in regular rows, spherical or subspherical, 2-3 µm in diameter 5-8 long, 4-6 wide; Planktic, epilithic; Distribution: St1 and St2; Cosmopolitan.

Genus: *Synechocystis* Sauvageau 1892
***Synechocystis* sp.** (Figure 4.h).
Cells solitary or agglomerated, but without common mucilage, spherical or slightly widely oval, 4-5 µm in diameter; Planktic; Distribution: St1 and St2

Genus: *Aphanocapsa* Nägeli 1849

Aphanocapsa* cf. *grevillei (Berkeley) Rabenhorst 1865 (Figure 5.a).

Colonies many-celled, with loosely or densely distributed cells; mucilaginous, cells spherical or slightly oval, 3-4 µm in diameter; Planktic; Distribution: St1.

Genus: *Snowella* Elenkin 1938

Snowella lacustris (Chodat) Komárek & Hindák 1988 (Figure 5.b).

Colonies spherical or irregularly oval, mucilaginous, Cells elliptical or slightly radially elongated, joined to the ends of stalks, 2-5 µm long, 1-3 µm wide, without gas vesicles; Planktic; Distribution: St1 and St2; Cosmopolitan.

Order: Oscillatoriales Cavalier-Smith

Family: Borziaceae Borzi 1914

Genus: *Komvophoron* Anagnostidis & Komárek 1988

Komvophoron constrictum (Szafer) Anagnostidis and Komárek 1988 (Figure 5.c).

Trichomes straight, 5-6 µm wide, not attenuated towards the end, constricted at the cross-walls, cells 2-4 µm wide, slightly constricted at the middle, apical cells rounded; Benthic, epiphytic; Distribution: St1 and St2; Cosmopolitan.

Family: Oscillatoriaceae (Gray) Harvey ex Kirchner 1898

Genus: *Oscillatoria* Vaucher ex Gomont 1892

Oscillatoria limosa* Agardh ex Gomont 1892 (Figure 5.d & e).

Trichomes straight 12-17 µm broad, not constricted at the granulated cross-walls, not attenuated at the ends, cells 3-4 µm long with mostly finely granular, apical cells flat-rounded or rounded with slightly thickened outer cell wall, without calyptra; Planktic, benthic, epipelic, epilithic; Distribution: St2; Cosmopolitan.

Oscillatoria ornata* var. *crassa Rao (Figure 5.f).

Trichomes straight, distinctly constricted at cross-walls, 10-14 µm wide. Cells always shorter than wide, 2-4 µm long. Apical cells rounded , without calyptra or thickened cell wall; Planktic, benthic, epipelic, epilithic; Distribution: St2; Cosmopolitan.

Oscillatoria princeps Vaucher ex Gomont 1892 (Figure 5.g).

Trichomes straight, not constricted at cross-walls, 20-24 µm wide. Cells always shorter than wide, 3-5 µm long. Apical cells rounded , with thickened cell wall; Planktic, benthic, epipelic, tychoplanktic; Distribution: St1 and St2; Cosmopolitan.

****Oscillatoria proboscidea*** Gomont ex Gomont 1892 (Figure 5.h).

Trichomes 10-16 µm broad, not constricted at the finely granulated cross wall, slightly curved at the ends, capitate, cells always shorter than wide, 3-4 µm long, apical cells rounded, with slightly thickened outer cell wall; Benthic, epiphytic, epilithic; Distribution: St1 and St2; Cosmopolitan.

Oscillatoria* cf. *annae Van Goor 1918 (Figure 5.i).

Trichomes straight, 7-9 µm wide, constricted at the cross wall, cells 3-4 µm long, apical cells rounded, without calyptra; Epilithic; Distribution: St1.

Oscillatoria* cf. *vizagapatensis Rao (Figure 5.j).

Trichomes straight, 7-10 µm wide, not constricted at the cross walls, slightly attenuated at the ends, cells 2-3 µm long, apical cells rounded-conical, without calyptra; Epilithic; Distribution: St1 and St2.

***Oscillatoria* sp.** (Figure 6.a).

Trichomes straight, 10-12 µm wide, constricted at the non-apparent cross walls, cells 6-7 µm long, apical cells rounded, without calyptra; Epiphytic, epilithic; Distribution: St2.

Family: Phormidiaceae Anagnostidis & Komárek 1998

Genus: *Phormidium* Kützing ex Gomont 1892

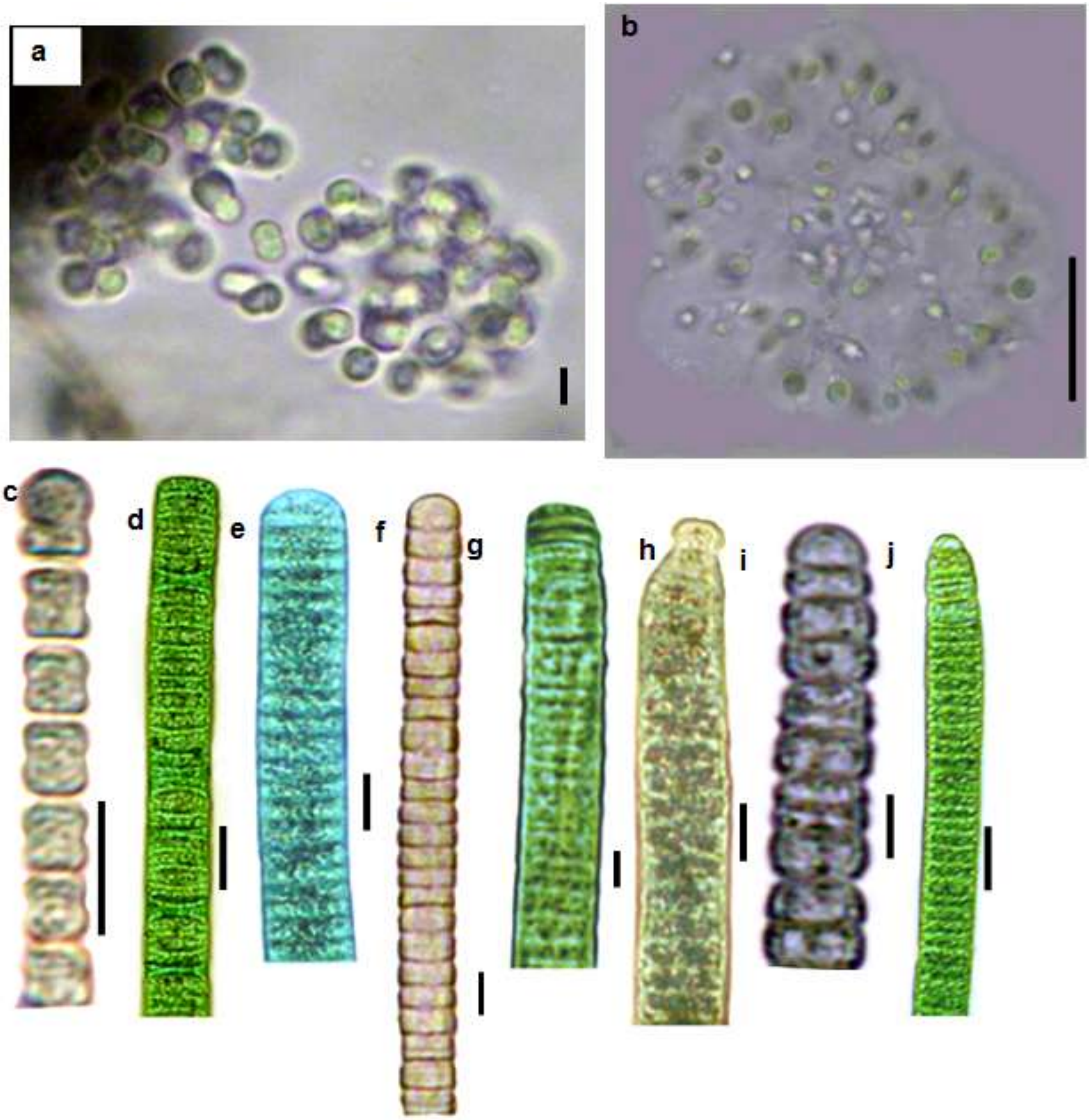

Figure 5.a-*Aphanocapsa* cf. *grevillei,* b-*Snowella lacustris*, c-*Komvophoron constrictum,* d & e-*Oscillatoria limosa,* f-*Oscillatoria ornata* var. *crassa,* g-*Oscillatoria princeps,* h-*Oscillatoria proboscidea,* i-*Oscillatoria* cf. *annae*, j-*Oscillatoria* cf. *vizagapatensis* (Scale bar =10µm)

Phormidium* cf. *simplicissimum (Gomont) Anagnostidis and Komárek 1998 (Figure 6.b).

Trichomes straight, 8-11 µm wide, not constricted at the cross-walls, not attenuated towards the ends cells 3-6 µm wide, with numerous granules distributed other the whole protoplast , apical cells capitate; Epilithic, epiphytic; Distribution: St1 and St2.

Genus: *Planktothrix* Anagnostidis & Komárek 1988

****Planktothrix compressa*** (Utermöhl) Anagnostidis & Komárek 1988 (Figure 6.c).

Trichomes straight, 5-9 µm wide, slightly constricted at the cross-walls, not attenuated towards the ends, cells 2-4 µm wide, with numerous gas vesicles distributed other the whole protoplast , apical cells widely rounded; Planktic, epiphytic, epilithic; Distribution: St2; Subcosmopolitan.

Planktothrix rubescens (De Candolle ex Gomont) Anagnostidis and Komárek 1988 (Figure 6.d).

Trichomes straight, 4-6 µm wide, not constricted at the granulated cross-walls, gradualy attenuated towards the ends, cells 3-5 µm, apical cells convex; Planktic, epilithic; Distribution:St2; Cosmopolitan.

***Planktothrix* sp.** (Figure 6.e).

Trichomes straight, 12-14 µm wide, cross-walls invisible, granules distributed other the whole protoplast; Epiphytic, epilithic; Distribution: St1.

Family: Pseudanabaenaceae Anagnostidis and Komárek 1988

Genus: *Leptolyngbya* Anagnostidis & Komárek 1988

*****Leptolyngbya polysiphoniae*** (Frémy) Anagnostidis 2001 (Figure 6.f).

Trichomes straight, 4-5 µm wide, constricted at the transparent cross-walls, cells very short, 1-2 µm, apical cells more long, convex, not capitate; Epiphytic, epilithic; Distribution: St2; Tropical zones.

Genus: *Pseudanabaena* Lauterborn 1915

Pseudanabaena catenata* Lauterborn 1915 (Figure 6.g & h).

Trichomes straight or sligtly bent, 2-3 µm wide, constricted at the thickened and hyaline cross-walls, not attenued at the end, cells cylindrical, 6-8 µm wide; benthic, epipelic, epilithic tychoplanktic; Distribution: St1 and St2; Cosmopolitan.

Pseudanabaena* cf. *limnetica (Lemmermann) Komárek 1974 (Figure 6.i).

Trichomes straight, 2 µm wide, not constricted at cross-walls, cells cylindrical, 6-8 µm long; Planktic; Distribution: St1.

Genus: *Spirulina* Turpin ex Gomont 1892

Spirulina gigantea Schmidle (Figure 6.j).

Trichomes 5 µm wide, regularly loosely screw-like coiled, 11-14 µm wide, distance between coiled 10 µm; Planktic, epiphytic, epilithic; Distribution: St1 and St2; Cosmopolitan.

****Spirulina meneghiniana*** Zanardini ex Gomont 1892 (Figure 6.k).

Trichomes 2 µm wide, with special pore and perforation patterns in the cell walls, nearly irregularly loosely screw-like coiled, 3-5 µm wide, distance between coiled 2-6 µm; Planktic, epiphytic, epilithic; Distribution: St1 and St2; Cosmopolitan.

Spirulina princeps West & G.S. West 1892 (Figure 6.l).

Trichomes green or olive-green with special pore and perforation patterns in the cell walls, 3-5 µm wide, regularly screw-like coiled, 10-12 µm, coils nearly parallel arranged not joined to one other, distance between coils 11-15 µm, 2-4 µm wide; Planktic, epilithic; Distribution: St1 and St2; Cosmopolitan.

Spirulina subsalsa Öersted ex Gomont 1892 (Figure 6.m).

Trichomes blue-green , 2-3 µm wide, regularly densely screw-like coiled, coils joined to one other , nearly parallel arranged, 2-4 µm; Epilithic; Distribution: St1; Cosmopolitan.

Cyanobacteria composition

In the samples from Adzopé's reservoir, a total of 33 taxa were identified belonging to 2 orders, 9 families, and 15 genera. There was a dominance of members of the orders Oscillatoriales (56.25%), Chroococcales (43.75%). Nine species and subspecies were recorded for the first time in Côte d'Ivoire, among them, *Geitleribactron periphiticum*. Highest species richness was observed on substrates (90.45% of the species, which were epilithic and epiphytic), in contrast to planktonic species. True planktonic species like *Microcystis aeruginosa*, *Microcystis novacekii*, *Planktothrix compressa and*

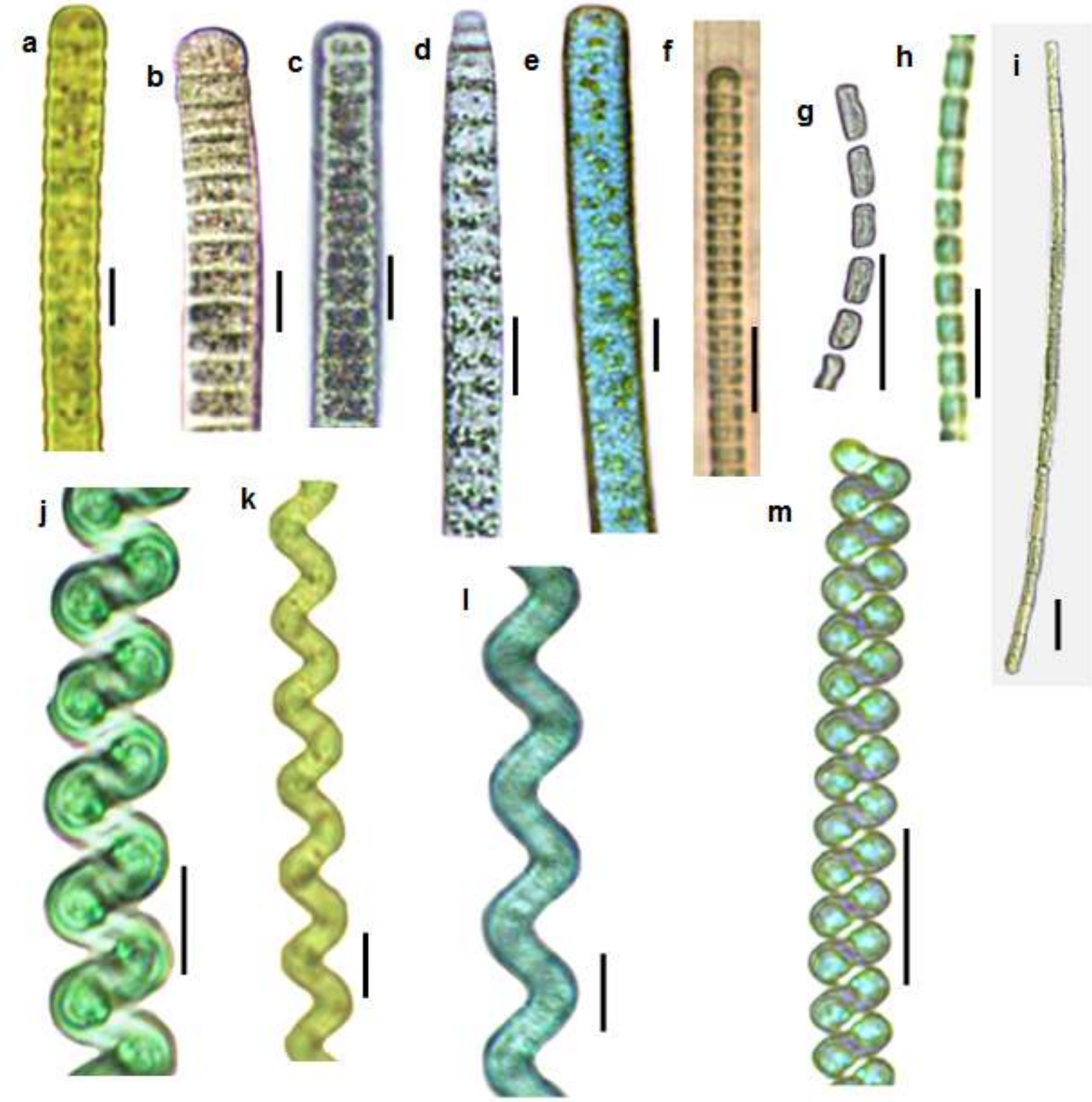

Figure 6. a-*Oscillatoria* sp., b-*Phormidium* cf. *simplicissimum,* c-*Planktothrix compressa,* d-*Planktothrix rubescens,* e-*Planktothrix* sp., f-*Leptolyngbya polysiphoniae,* g & h-*Pseudanabaena catenata,* i- *Pseudanabaena* cf. *limnetica*, j-*Spirulina gigantea,* k-*Spirulina meneghiniana,* l-*Spirulina princeps,* m-*Spirulina subsalsa* (Scale bar =10µm)

Planktothrix rubescens were either recorded on substrates. No spatial variations in the taxonomic composition of the populations of Cyanobacteria were found. Variations were only encountered in the seasonal analysis. Species richness was weakly represented during rainy seasons and hightly during dry seasons. The highest species richness (26) was obtained in February during the long dry season; the lowest (9) was registered in June during the long rainy season (Table 2).

The spectrum of the meaningful species points out that a very low number of species contributed significantly to the Cyanobacteria occurence. In fact, among the 33 species recognized, just 5 contributed at least once during the sampling period to build up the 50% of the frequency of each species present

(*Microcystis aeruginosa*, *Planktothrix rubescens*, *Geitleribactron periphyticum, Spirulina subsalsa, Oscillatoria princeps*).

Among these species, *Microcystis aeruginosa* exceeded the 90% of occurrence during long dry season, when the occurrence of *Planktothrix rubescens* was low (48,19%). During the rainy seasons occurrence of *Microcystis aeruginosa* remained constantly over 60%, when *Planktothrix rubescens* became dominant (75.35% of occurrence). During short dry season, the frequency of occurrence of these 2 Cyanobacteria were 71.88% and 73.21 respectively for *Microcystis aeruginosa* and *Planktothrix rubescens*.

Discussion

Based on the threshold values for different trophic states suggested by Forsberg and Ryding (1980), the measured Secchi disk transparency for the Adzopé Reservoir and the nutrient charges place it in a eutrophic category.

Species richness of Cyanobacteria in this reservoir is more important than that recorded by Kleber and Célia (2010) from different types of lakes in Brazil but less important than that recorded by Compère (1974) from Lac Tchad.

The richness of this reservoir can be explained by the fact that Cyanobacteria are often associated with eutrophic conditions and high temperatures (Shapiro, 1990), low luminosity (Niklisch and Kohl, 1989), alkaline pH (Reynolds and Walsby, 1975), high concentrations of nutrients, especially phosphorus (Watson *et al.*, 1997), and buoyancy regulation (Walsby *et al.*, 1997). The species *Geitleribactron periphiticum* has not been reported in Côte d'Ivoire reservoirs in previous works because it is a periphytic taxa which growth on mollusc shells, stones, leaves of water plants and mosses, filamentous algae (Komárek and Anagnostidis , 1999) and no previous works had been devoted to these kind of taxa. The presence of true planktonic species on substrates may be related to their sedimentation on this substrates due to the very low velocity of the current of the reservoir.

Of the identified taxa, 64.73% are common to Côte d'Ivoire lakes, reservoirs, and ponds (Bourrelly, 1961; Uherkovich and Rai, 1977; Ouattara et *al.*, 2000).

Seasonal variations in the taxonomic composition can be explained by the stability of the water column (Berger et *al.*, 2006) and the long period of water retention during long dry season in the reservoirs providing excellent conditions of temperature and irradiation (Bouvy et *al.*, 2000). Decreasing of species richness with the rainy season might be attributable to the reduced nutrient charge, dilutional effects of rain (Kouassi *et al.*, 2013) and the current velocity. The hight occurrence of *Microcystis aeruginosa* during dry seasons seems to be associated with the fact that this species, a S-strategist organism (Reynolds, 1997) is well adapted to grow at the high light intensity of the surface waters (Legnani *et al.* 2005).

The hight occurrence of *Planktothrix rubescens,* a R-strategists organism (Reynolds, 1997) during the long rainy season is due to the fact that this cyanobacteria is well adapted to low light intensity (Legnani *et al.*, 2005). Endeed, the presence of an efficient accessory pigments apparatus (constituted by phycobiline and phycoerythrin proteins) wich is able to intercept the whole spectrum (400-700 nm) of the incoming Photosynthetic Active Radiation (PAR) and to perform active photosynthesis at very low values of irradiance (Reynolds, 1997; Chorus and Bartram, 1999). In contrast, it slow frequency of occurrence during long dry season can be explained by the fact that this species is photoinhibited in conditions of high irradiance (Chorus and Bartram, 1999). The coexistence of the two Cyanobacteria types found during the short dry season can be interpreted as an example of temporal transition between these 2 dominant taxa favouring the

Table 2. List of taxa observed in the Adzopé Reservoir (F : species occurrence frequency , * presence, LDS : long dry season, LRS : long rainy season, SDS : short dry season, SRS : short rainy season)

	F	LDS	LRS	SDS	SRS
Geitleribactron periphyticum	3	*	*	*	*
Aphanothece stagnina	2	*			*
Aphanothece sp.	1				
Chroococcus dispersus	2	*		*	
Chroococcus minutus	1	*			*
Chroococcus turgidus	1	*		*	
Microcystis aeruginosa	3	*	*	*	*
Microcystis novacekii	1	*			*
Microcystis sp.	1	*		*	
Merismopedia elegans	2	*		*	
Merismopedia punctata	2	*		*	
Synechocystis sp.	1	*			
Aphanocapsa cf. *grevillei*	1	*			
Snowella lacustris	1	*			*
Komvophoron constrictum	2	*		*	*
Oscillatoria limosa	2	*			*
Oscillatoria ornata var. *crassa*	1			*	
Oscillatoria princeps	3	*	*	*	*
Oscillatoria proboscidea	2	*		*	*
Oscillatoria cf. *annae*	1	*		*	
Oscillatoria cf. *vizagapatensis*	1	*		*	
Oscillatoria sp.	1	*	*		
Phormidium cf. *simplicissimum*	2		*	*	
Planktothrix compressa	2	*		*	
Planktothrix rubescens	3	*		*	*
Planktothrix sp.	1	*			
Leptolyngbya polysiphoniae	1	*		*	
Pseudanabaena cf. *limnetica*					
Pseudanabaena catenata	2	*	*		*
Spirulina gigantea	1		*		
Spirulina meneghiniana	2				*
Spirulina princeps	1			*	
Spirulina subsalsa	3	*	*	*	*
		26	9	19	14

decline of *Planktothrix rubescens* and the increase of *Microcystis aeruginosa*.

The high occurrence of *Planktothrix rubescens* and *Microcystis aeruginosa* in Adzopé reservoir, which are potential toxin producers therefore must constitute a concern for authorities that monitor the quality of public drinking water.

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