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Identification and taxonomic studies of *Scenedesmus* and *Desmodesmus* species in some Mbanza-Ngungu ponds in Kongo Central Province, DR Congo

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ABSTRACT

***Scenedesmus* and *Desmodemus* are two genera belonging to the *Scenedesmaceae* family. The present study sampled two genera of micro-algae in three ponds located at Mbanza-Ngungu, Kongo Central Province, DR Congo. In the study, 14 species (10 species of *Scenesdemus* and 4 species of *Desmodemus*) from the two genera were identified and described. They include *Scenedesmus acuminatus* (Lagerheim) Chodat, *S. alternants* Reinsh, *S. armatus* (Chodat) G. M. Smith, *S. dimorphus* (Turpin) Kuetzing, *S. quadricauda* (Turpin) Brebissonii, *S. ecornis* [Ehrenberg, Chodat, *S. obliquus* (Turpin)], *Scenedesmus* sp., *Desmodesmus abundans* (Kirchner) E. Hegewald, *D. intermedius* (Chodat) E. Hegewald, *D. magnus* (Meyen) Tsarenko and *D. opoliensis* (P.G. Richter) E. Hegewald. The diversity of these two genera species is greater in Kola pond and mostly in Voke.**

INTRODUCTION

Like all aquatic ecosystems, ponds are ecosystems that are rich in freshwater micro-algae. They contain nearly all the algal groups except Rhodophyta and Phaeophyceae (Zongo et al., 2008). Mbanza-Ngungu ponds present a diversity in micro-algae. Two dominant micro-algae genera present in these ponds are *Scenedesmus* and *Desmodesmus*. Both genera are green algae belonging to Chlorophyceae class and Chlorophyta phylum. Seventy-four *Scenedesmus* sp. have been recorded. Several subgenres were identified. Three of the subgenres were considered to be genera. These are*:* *Acutodesmus*, *Desmodesmus* and *Scenedesmus*. *Acutodesmus* is characterized by sharp cell apex. *Desmodesmus* and *Scenedesmus*, however, have tracked down poles.

Former studies stopped considering *Acutodesmus* as a genus. Many writers analyzed 18 S-ADNP gene sequences. The results did not support *Acutodesmus* as being a genus*. Desmodesmus* and *Scenedesmus*, however, were confirmed as genera belonging to *Scenedesmaceae* family (Hegewald and Braband, 2017). Several studies sustain these truths. Systematic studies bear some confusions between *Scenedesmus* and *Desmodesmus*, that they share species, but the greater number is given to *Scenedesmus.*

Membrane structures are means of protection against predators. *Scenedesmus* membrane layers constitute passive zones of heavy metals and radio nuclides absorption. These physiological movements concentrate inside the cell. The process helps *Scenedesmus* to accumulate cadmium up to 0.3% of its weight. *Scenedesmus* also accumulate molybdenum up to 2% of its weight. This property has enable these species to be used for the recovering of heavy metals and in mitigation projects of waters rich in heavy metals (Gudin, 2013).

Scenedesmus is recognized to have high biomass productivity among green algae and was greatly sought for its use in biodiesel production.

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MATERIALS AND METHODS

Field works mainly took place in three ponds (Kola, Nua and Voke) in Mbanza-Ngungu in Kongo Central Province. Mbanza-Ngungu has a wet tropical weather with the savannah as vegetation growing in a clayey and sandy soil.

Kola

This pond is surrounded by houses. It is located at longitude 14° 3850, 4'' East and latitude 05° 23'36, 8'' South, at an altitude of 558 m above sea level. Its area is totally covered by flowing plants forming a more or less 30 cm thick cloth. This cloth has uncovered places in the centre where water is directly lit by the sun. The pond bed is muddy.

Nua

Nua is located in the North-East of Mbanza-Ngungu. Its altitude is 685 m above sea level, with longitude 14° 53'31, 7'' East and latitude 05° 24'52, 1'' South. It is oval-shaped. It is 400 m long and more or less 120 m wide. Its area is totally covered by aquatic macrophytes.

Voke

This pond is 17 km away in the South of Mbanza-Ngungu. It is located at longitude of 14° 36' 3'' East and latitude of 05° 27' 54 3'' South; and has an altitude of 558 m above sea level. The basin is 300 m long and 200 m wide. Its bed has clayey mud. The pond is not covered. A green belt surrounds it. This belt is 3 to 7 m wide depending on the season and places.

In Kola pond, sampling sites were localized at the central part where open areas were seen. In Nua and Voke ponds, sampling sites were localized in the periphery. A WTW 340i multiparameter (Wissen schaftlich-Technische Werkstätten GmbH, Germany) having interchangeable drill was used to measure conductivity, pH, dissolved oxygen and temperature on ground. Micro-algae were collected using plankton net with mesh size of 20 µm. At each sampling site, water physical parameters were measured using a WTW 340i multiparameter bearing interchangeable drill. Physical parameters include dissolved oxygen, temperature, pH and conductivity.

A Motic BA 310 binocular microscope (Motic China Group, Ltd) was used to have micro-algae observations and their pictures in the laboratory. This microscope had a camera connected to a PC with a "measure" software helping to measure the dimensions of micro-algae observed and the water samples collected in 1 L plastic bottles. Analyses of the samples were carried out in the Laboratory of Soil Physics and Hydrology of the Atomic Energy General Station in Kinshasa.

Identified taxa

The description and photos obtained helped identify the species comparing the data obtained with previous reports (Bourrelly, 1988 and 1990; Compere, 1967 and 1977; Iltis, 1980; Da Kourete 1997; Delazari-Barroso, 2007; Gayral, 1975; Islam and Haseel, 2005; Lürling, 1998; Noba, 2009).

RESULT

The results of physico-chemical parameters measured reveal that waters from the three ponds under study are acid and less mineralized. This explains the low conductivity. The highest temperature was recorded in January 2013 at Voke (28°C). The lowest temperature was recorded in September 2012 at Nua (22.1°C). Conductivity values were between 29 and 145 µs/m. The highest dissolved oxygen value was 1.82 mg/L. Table 1 gives the principal physic-chemical parameters measured.

The measures on ground and laboratory analyses gave an idea about the concentration of physic-chemical elements from the waters of Kola, Nua and Voke ponds (Table 1). All these factors contribute to the development of micro-algae, but they do not have the same value in their biology. As these factors are numerous, the analysis in principal component (APC) presents those that are the most determining in the biology of the pond algae under study (Table 2).

The three components put together (Table 2) represent an extraction of the total variance explained at 55.367%. This rate is clearly above the acceptable (50%). This supports the deriving analyses results.

Extracted components

Table 3 clearly indicates the factors and components to which they belong. It is just a matter of corresponding the components to each factor where the best performance in absolute value is found. According to Rambhujun and Berrain (2008), it is the first component which gives the greatest amount of information.

Component 1 (55. 367%) has useful factors for the existence of micro-algae, nitrite, calcium, free bromine, pH, free Iodine, magnesium, potassium, chromium and temperature are very useful in the life of ponds algae under study.

Table 1. Principal physico-chemical parameters in the three ponds (Kola, Nua and Voke).

Physico-chemical factors	September 2012			November 2012			January 2013			March 2013			April 2013			July 2013			Unity	Guide values
	KOLA	NUA	VOKE	KOLA	NUA	VOKE	KOLA	NUA	VOKE	KOLA	NUA	VOKE	KOLA	NUA	VOKE	KOLA	NUA	VOKE		
Conductivity	29	48	31	64	59	35	60	50	38	50	37	34	52	45	37	73	68	34	µs/m	100
pH	4.15	4.06	4.60	4.46	6.09	5.53	4.42	4.66	5.79	4.72	4.66	5.47	4.70	5.30	5.31	5.3	5.50	6.30		
Temperature	22.3	22.1	22.9	24.6	26.3	26.6	27.4	27.3	28.7	27.8	25.5	27.6	25.7	25.7	28.1	23.2	24.7	24.5	°C	
Dissolve Oxygen	6	5	3	7	7	6.5	5	6.5	6	8	3	5	7.5	6	7	5	7	9	mg/l	
Magnesium	0.06	0.03	0.02	1.09	2.07	0.87	0.66	0.55	0.18	0.63	1.91	1.43	0.26	0.40	0.17	1.11	0.75	0.91	mg/l Mg^{2+}	100
Calcium	0.81	0.72	0.32	1.17	57.6	1.18	0.53	0.32	0.69	0.97	4.47	1.82	2.41	1.44	1.06	0.57	0.19	0.84	mg/lCa^{2+}	30
Potassium	6.2	3.7	7.7	4.9	2.3	2.2	4.1	3.6	6.3	2.5	2.1	5.4	3.3	4	2.6	3.8	7.4	4.6	mg/l K^{+}	10
Ammoniac	0.15	0.09	0.05	0.09	0.10	0.13	0.09	0.09	0.06	0.10	0.07	0.11	0.09	0.1	0.09	0wx9	0.09	0.11	mg/l NH_3-H	1.5
Chromium	0.023	0.032	0.034	0.029	0.041	0.047	0.031	0.037	0.044	0.027	0.022	0.024	0.014	0.018	0.022	0.027	0.014	0.026	mg/l Cr^{6+}	0.05
Total Iron	0.12	0.26	0.13	0.19	0.38	0.21	0.17	0.34	0.23	0.026	0.16	0.041	0.32	0.58	0.047	0.31	0.56	0.14	mg/lIron	0.3
Silica	9.8	72.4	0.6	5.8	2.1	5.5	4.6	88	28.4	1.7	111.2	2.1	1.2	70.2	1.6	0.3	21.1	10.1	mg/l SiO_2	
Free Chlorine	1.90	1.28	1.22	0.39	0.38	0.32	0.41	0.38	0.59	0.04	1.8	0.75	0.16	0.84	0.30	0.11	0.06	0.44	mg/l Cl_2	5
Free Bromine	0.016	0.006	0.012	0.46	0.61	0.64	0.0084	0.089	0.093	0.019	0.003	0.004	0.041	0.06	0.046	0.037	0.38	0.80	mg/l Br_2	0.01
Free Iodine	0.045	0.019	0.028	0.43	1.02	0.98	0.0043	0.090	0.098	0.035	0.016	0.037	0.51	1.22	0.80	0.31	0.55	0.98	mg/l I_2	
Nitrate	2.1	0.1	0.9	0.51	0.4	0.3	1.9	2.2	1.3	4.2	5.8	23.4	0.6	2.5	7.3	6.3	1.7	4.2	mg/l NO^{-}_3	50
Nitrite	0.009	0.004	0.0067	0.010	1.448	0.014	0.006	0.096	0.003	0.001	0.006	0.005	0.071	0.026	0.0118	0.029	0.023	0.007	mg/l NO^{-}_2	0.1
Phosphorus	0.21	1.41	0.13	2.25	44.8	7.32	2.74	55.36	1.28	5.21	58.41	7.16	1.29	11.97	1.53	1.27	11.97	1.45	mg/l $P0^{3-}_4$	3
Chloride	1	22.11	16.5	0.78	28.19	19.8	1.851	18.675	14.68	16.50	34.05	21.45	4.455	6.765	2.145	3.13	4.62	1.65	mg/l Cl	250
Sulphate	0.66	3	2	2	4	2	14	7	4	1	2	2	2	3	2	7	4	2	mg/l so_4^{2-}	250

Table 2. Total variance.

Components	Extraction: squares sums of factors kept (Cumulated %)
1	23.300
2	43.397
3	55.367

Extraction method: Analysis of principal components.

Table 3. Components matrix.

	Components		
	1	2	3
Nitrite	0.822	0.217	0.087
Calcium	0.815	0.255	0.036
Free Bromine	0.726	-0.312	-0.095
pH	0.687	-0.194	-0.248
Free Iodine	0.685	-0.362	-0.004
Magnesium	0.643	0.413	-0.134
Potassium	-0.450	-0.257	0.149
Chromium	0.304	0.251	-0.122
Temperature	0.283	0.070	-0.273
Chloride	0.245	0.858	-0.266
Free chlorine	-0.262	0.802	-0.093
Phosphorus	0.426	0.736	0.101
Silica	-0.139	0.700	0.215
Oxygen	0.478	-0.690	-0.083
Ammoniac	0.218	-0.458	-0.356
Conductivity	0.277	-0.143	0.762
Total Iron	0.363	0.033	0.722
Nitrate	-0.131	0.110	-0.594
Sulphate	0.004	0.076	0.584

Extraction method: Analysis of principal components.

Component 2 represents a 43.397 variance. It contains chloride, free chlorine, phosphorus, silica, oxygen and ammoniac contributing in second position to the life of algae.

The identification of subjects was carried out using a Motic BA 310 binocular microscope. The observation and photograph were accomplished with 400×: ocular with 40× objective. The description of species genera with figures are given below.

Scenedesmus acuminatus (Langerheim) Chodat

The observed colony has eight cells. They are falciform. Each colony half has its cavity giving outside. The cell dimension is 17.8×3.5 µm. The species is found in Voke pond (Figure 1).

Scenedesmus alternans Reinsch

This eight-cell colony is alternatively presented as zigzag. The marginal cells are very small. The median cells, however, are big and trapezoidal-shaped with a rounded apex. The cell dimension is 20×6 µm. This species was collected from Voke pond (Figure 2).

Scenedesmus armatus (G.M. Smith) Chodat

This colony has two to four cells. The subjects colony measure 12×4 µm. Each cell presents two thorns and each thorn has a medio-longitudinal crests. This species was collected from Kola and Voke ponds (Figures 3).

Scenedesmus dimorphus (Turpin) Kuetzing

This colony has four fusiform cells with sharp poles. The marginal cells have convex external edge in the central part. The central cells have a 20–25×2.5-4 µm dimension. The species was collected from Kola and Voke ponds (Figures 4).

Scenedesmus javanenses Chodat

This colony has eight fusiform cells that are slightly incurved with sharp extremities. The cells are alternatively presented in contact with their tops and the median part of adjacent cellsin a linear series. The cell membrane is smooth. This species was collected from pond Voke (Figure 5).

Scenedesmus naegelii Brebisson

This colony has eight 21×8 µm cells. The marginal cells present two thorns, the central cells are on one side for each series of two or three cells and the opposite pole to the one that bears the thorn that can or cannot support a protuberance. The median cells often have an oblique disposition to the marginal ones. (Da. KP, 1977). This species was found in Kola and Voke ponds (Figure 6).

Scenedesmus ecornis (Ehrenberg) Chodat

This colony has four ovoid cells. These cells are ellipsoidal with sharp poles and without thorns, spines and crests. Each cell is 10 µm long and 7 µm wide. This species was collected from Kola (Figure 7).

Scenedesmus quadricauda (Turpin) Brebisson

This colony is rectangular. It has two, four, or eight cylindrical cells with rounded ends. Each marginal cell has two thin, recurved and more or less twisted thorns. The cell dimension is 28×3 µm. This species was collected in Kola and Voke ponds (Figures 8).

Scenedesmus obliquus (Turpin) Kützing

The cells measure 16×5 µm. They are reniform with

Figure 1. *Scenedesmus acuminates* (Langerheim) Chodat.

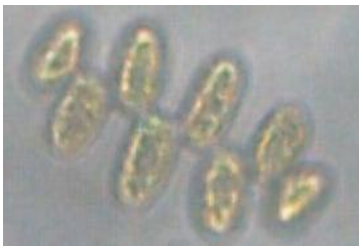
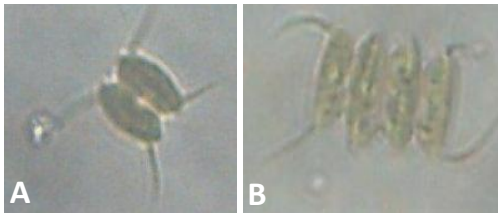
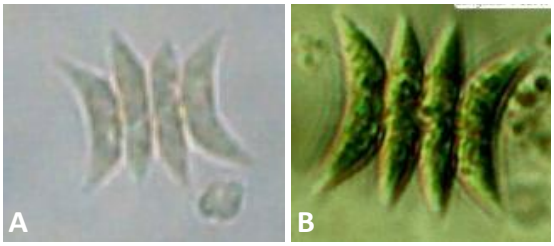
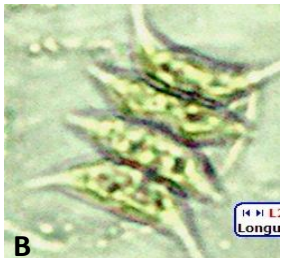


Figure 2. *Scenedesmus alternans* Reinsch.



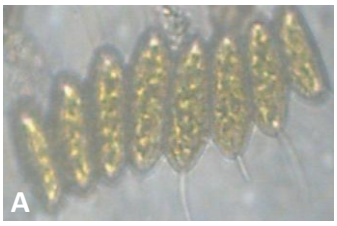
Figures 3. *S. armatus* (G.M. Smith) Chodat.





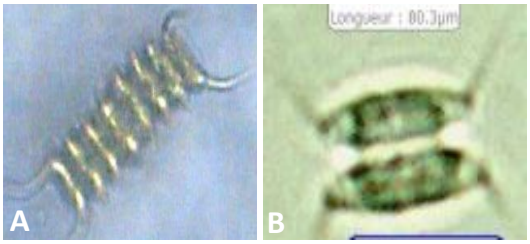
Figures 4. *S. dimorphus* (Turpin) Kuetzing.

Figure 5. *S. javanenses* Chodat.

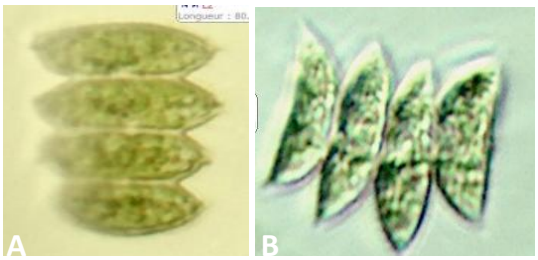


Figures 6. *Scenedesmus naegelii* Brebisson.

Figure 7. *S. ecornis* (Ehrenberg) Chodat.



Figures 8. *S. quadricauda* (Turpin) Brebisson.



Figures 9. *S. obliquus* (Turpin) Kützing.

Figure 13. *D. magnus* (Meyen) Tsarenko.

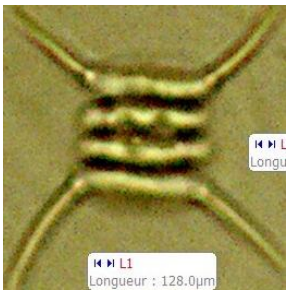
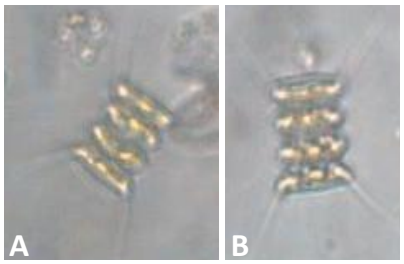


Figure 10. *Scenedesmus* sp. 1.

spines at poles. They have no thorn. They form colony of four cells. It was collected from Kola (Figures 9).

Scenedesmus Sp.

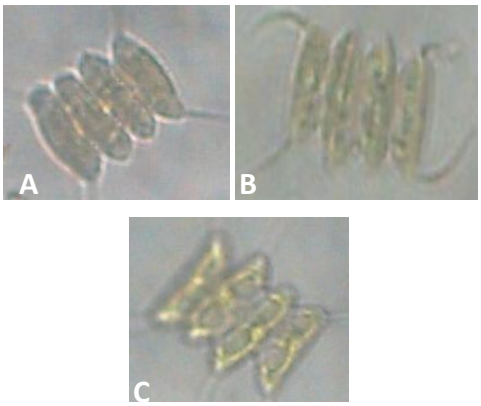
The colony has four cylindrical cells attenuated at poles. Each marginal cell has two stiff and sharp thorns. The cells dimensions are 10×2 µm. This species was collected from Kola (Figure 10).



Figures 11. *D. abundans* (Kirchner) E. Hegewald.

***Desmodesmus abundans* (Kirchner) E. Hegewald**

This colony has four ovoid cells united by a frost. Each marginal cell bears two thorns. Each cell has a chloroplast with a pyrenoid. The cell dimension is 9–13×2, 3–4 µm. This species was collected from Voke pond (Figures 11).



Figures 12. *D. intermedius* (Chodat) E. Hegewald.

***Desmodesmus intermedius* (Chodat) E. Hegewald**

This colony has four ovoid cells. Each central cell presents to the pole a thorn in opposite direction. The marginal cells have two recurved cells which are not oriented clockwise. Each cell has a 22–25×8 µm dimension. This species was found in Kola and Voke ponds, but was more abundant in Voke (Figures 12).

***Desmodesmus magnus* (Meyen) Tsarenko**

This colony has four cylindrical and lengthened cells. Each marginal cell has two spines at each pole. The cells are surrounded by mucilage. Each cell has a 12×3, 8 µm dimension. This species was collected from Voke pond (Figure 13).

***Desmodesmus opoliensis* (P.G. Richter) E. Hegewald**

This colony is composed of four fusiform cells attenuated

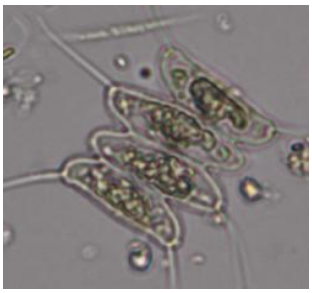


Figure 14. *D. opoliensis* (P.G. Richter) E. Hegewald.

at poles and tied up on 1/3 or ½ of their length. The external cells have thorns at two poles as well as the longest internal cell. The cells dimensions are 15×6 µm. This species was collected from Voke pond (Figure 14).

DISCUSSION

As far as the physic-chemical parameters are concerned, the pH was acid in all the ponds. Water temperatures vary between 22.1 and 28.7. The mean concentration of mineral elements determined low conductivity (29-68 µs/m).

Among the nutriments and climate factors, nitrite, calcium, free bromine, pH, free iodine, magnesium, potassium, chromium and temperature determined the life of micro-algae as well as *Scenedesmus* and *Desmodesmus* in Kola, Nua and Voke ponds.

Seventy-four taxomic species of *Scenedesmus* genus are admitted. Da et al., (1997) studied *Scenedesmus* from the pisciculture complex of the National Park of Banco (Ivory Coast). However, they did not speak about *Desmodesmus*. The latter which is derived from *Scenedesmus* must be young as Hegewald indicated. This youth state is confirmed by the greater number of *Scenedesmus* sp. compared to that of *Desmodesmus* (10 against 4) in the 3 ponds (Kola, Nua and Voke ponds). The biological, physiological and systematic study revealed the importance of Scenedesmus.

Conclusion

This study results demonstrate the diversity of *Scenedesmus* and *Desmodesmus* spp in Mbanza-Ngungu ponds. Koa and Voke share different species of both genera. Fourteen species were found. Among them, ten species belong to *Scenedesmus*. They are composed of 2, 4 and 8 cells in various forms. It is a characteristic polymorphism: cylindrical, ovoid, fusiform, falciform, elliptical, moon-crescent shaped cells. Their extremities can be rounded or sharp bearing or not bearing thorns. These various forms made the determination of species difficult. Bourrelly (1988), cited by Da Kourete (1997), specified that the systematic determination of *Scenedesmus* spp. is very embarrassing. The polymorphism of these species is very marked.

S. quadricauda and *Scenedesmus naegelii* are the species that are the most represented especially in Voke pond.

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