

Seasonal variations in phytoplankton diversity in the Bui dam area of the Black Volta in Ghana during the pre- and post-impoundment periods

Elliot Haruna Alhassan

Department of Fisheries & Aquatic Resources Management, University for Development Studies, P. O. Box TL 1882, Tamale, Ghana; ehalhassan@gmail.com

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Abstract: Phytoplankton constitutes the primary producers of aquatic ecosystems and represents the food chain base that supports the commercial fisheries of most water bodies. Nowadays, there is lack of information on phytoplankton assemblages of most reservoirs in Africa. To contribute with this knowledge, this study was carried out to determine the density and diversity of seasonal variations of phytoplankton species in the Bui dam area of the Black Volta, during the pre- (2011) and post-impoundment (2012) periods. For this, a three-level stratified random sampling approach was adopted for 22 months. Phytoplankton samples were obtained by towing a 0.5m diameter phytoplankton net (35 μ m mesh size and 0.25m² mouth surface area) from a non-motorized canoe through a distance of about 100m against the current from downstream to upstream of the river. In 2011, 35 species of phytoplankton belonging to four classes, Bacillariophyceae (7.6%), Chlorophyceae (43%), Cyanophyceae (48.6%) and Euglenophyceae (0.8%) were identified. In the 2012 sampling, 18 species belonging to three classes, Bacillariophyceae (2.2%), Chlorophyceae (26.1%) and Cyanophyceae (71.7%) were observed. A total of 17 species of phytoplankton, including *Gyrosigma* sp., *Surirella* sp., *Carteria* sp., *Chlosterium* sp., *Chlorogonium* sp., *Coelastrum* sp., *Cosmarium* sp., *Volvox* sp., *Chroococcus* sp., *Coelosphaerium* sp., *Rivularia* sp. and *Spirulina* sp., were absent during the late post-impoundment period. Mean monthly total phytoplankton abundance decreased from June (7 384 cells/m³) to August (106cells/m³) in 2011. In 2012 however, mean total phytoplankton decreased from February (1 237cells/m³) to August (4cells/m³). The results also showed that variations occurred between seasons among some phytoplankton groups. The dry and pre-wet seasons had significantly ($p < 0.05$) higher mean phytoplankton abundance than the wet season during the 22 months of sampling period. The biotic indices of Shannon-Wiener (H^1) were homogenously distributed in the four hydrological seasons of the two years. The phytoplankton groups, Bacillariophyceae, Chlorophyceae, Euglenophyceae and total phytoplankton differed significantly ($p < 0.05$) between the pre- and post-impoundment periods. The total phytoplankton was also significantly ($p < 0.05$) higher in the upstream station than the downstream station indicating the impact of the impoundment on the downstream ecology. Hence, river management strategies should be implemented by hydro-biologist to lessen the impact of the dam on the downstream ecology. Rev. Biol. Trop. 63 (1): 13-22. Epub 2015 March 01.

Key words: impoundment, chlorophyceae, cyanophyceae, seasonal density, downstream station.

The creation of dams is known to be implicated in negative human impacts on river ecosystems as they modify physical environment and regulate flow (Allan, 1996). According to Junk, Bayley and Sparks (1989), dams interrupt stream flow and generate hydrological changes along the integrated continuum of river ecosystems that ultimately reflect in the fisheries and hydro-biology of rivers. The most obvious

effects of placing dams on rivers result from the formation of new lentic environments upstream from the dam and tail water environment downstream of the dam (FAO, 2001). Cumulative effects of dams in catchment basins and tributary streams can significantly block nutrient flow, affecting plankton in river channels (Hess, Schlesinger, Hergenrader, Reetz & Lewis, 1982).



Despite these negative impacts, the number of damming projects worldwide keeps increasing purposely for the generation of hydroelectric power, irrigation and flood control. The Government of Ghana is contributing to the global increase in dams by creating another dam at the Bui gorge on the Black Volta in addition to the existing Akosombo and Kpong dams for the generation of hydroelectric power. The Bui dam will create a reservoir covering an area of about 444km² at full supply level (FSL) of 183 meters above sea level (masl) and holding about 12 600 million m³ of water which will be used for the generation of electricity. Most of the reservoir area will be contained within the nearby Bui National Park. The dam created by the Bui barrage is expected to impact through inundation, the assemblages of fishes, plankton and macro-benthic fauna.

Communities inhabiting the dam can be classified based on their position in the energy level: producers; consumers and decomposers (Visser, 1970). Primary production by algae in the water sets the level of food available for secondary producers such as zooplankton and fish. When nutrient availability is high, overall production varies with water temperature (Hewett, & Johnson, 1987). It is likely that rates of primary production will be altered by climate change and may result in significant consequences for aquatic ecosystems and the human communities that use them. Decreases in primary production on the one hand, will reduce food availability at the bottom of the food web; ultimately causing reductions in productivity of fish at the top of the food web while on the other, excessive increases in primary production will produce eutrophic conditions, exemplified by degraded water quality and noxious blue green algal blooms.

Differences in the water temperature, transparency and nutrient level produces changes in the phytoplankton composition (Tundisi, 1993), which can be seen up to 350km downstream from the Yacyreta dam in Argentina (Petts, 1984). The whole algal fauna of the Volga

River was modified after the conversion of the river into a cascade of reservoirs (Mordukhai-Boltovskoi, 1979). The phytoplankton of the Dniester River likewise underwent qualitative and quantitative changes after the closure of the Dubassery reservoir with increases in Cyanophyceae downstream of the dam. The phytoplankton biomass varied between 0.66-0.85g/m³ before the dam was built but rose to 4g/m³ after its construction (Welcomme, 1985). In the Nile River at the Gebel Aulia dam, the dam slowed the Nile current and produced a rapid increase in phytoplankton concentration. When the dam was opened, the flow was faster and phytoplankton concentration dropped, hence demonstrated a strong correlation between phytoplankton and current velocity in the river (Prowse, & Talling, 1958). According to Rzoska and Talling (1966), phytoplankton was more abundant in the backwaters of the Nile Sudd than in the main channels, thus Rzoska (1974) obtained values of between 40 and 140cells/mL for the river, whereas densities in lagoons were between 1 720 and 2 330cells/mL. In the Tagwai Dam in Nigeria, phytoplankton species diversity showed that Cyanophyceae had three genera, Bacillariophyceae (10), Desmidiaceae (3) and Chlorophyceae (15) (Kolo, Ojutiku, & Musulmi, 2010).

Soon after the creation of the Volta Lake in Ghana as a result of the construction of the Akosombo dam, Blue-green algae dominated the phytoplankton population increasingly towards the extremities of the Lake arms where the water column was both shallower and more sheltered from turbulence by wind (Viner, 1970). It is anticipated that similar changes in the density and diversity of phytoplankton of the Black Volta would take place soon after the creation of the Bui dam. The present study has, therefore its specific value, for assessing the phytoplankton species abundance and diversity of the Black Volta in the Bui dam area during the pre- and post-impoundment periods. This will generate information on the floral characteristics in both periods of river impoundment.

MATERIALS AND METHODS

Study site: The study was carried out for 22 months (March 2011-December 2012) on the Bui dam section of the Black Volta in Ghana. The study area stretched from the Bui reservoir (upstream) to Bamboi (downstream) within 8°09' - 8°16' N - 2°01' - 2° 15' W and a distance of about 37.5km. The Bui dam will create a reservoir covering an area of about 444km² at full supply level (FSL) (at 183masl) and holding about 12 600million m³ of water which will be used for the generation of electricity and reservoir volume at FSL (m³) of 12.57x10⁹. There is considerable variation in local relief of the Black Volta basin. The Northern areas ranged from 300-600masl. The Basin is gently undulating from the North to the South. Most part of the Black Volta falls under the Savanna zone which is undulating with gentle slopes that promotes overland flow. The low relief is also a cause for the poor surface drainage with a consequent flooding which characterize the desertification-prone areas during the wet season (Agorsah, 2004).

Sampling design: In order to provide an all-year picture of the hydro-biology of the study area, a three-level stratified random sampling approach was adopted. The first stratum, defined by the four designated hydrological seasons in the study area, was referred to as follows: dry season (January to March); pre-wet season (April to June); wet season (July to September); and post-wet season (October to December) (Abban, Kwarfo-Apegyah, & Amedome, 2000). The second stratum, defined by the three impoundment periods in the study area, was referred to as: pre-impoundment (March to May 2011); immediate post-impoundment (June to December 2011); and late post-impoundment (January to December 2012). The third stratum was related to the sampling stations as follows: above the dam site or reservoir area with sampling station at Bui (old town currently submerged); and below the dam site area with sampling station at Bamboi.

Collection and enumeration of phytoplankton samples: Triplicate phytoplankton samples were collected monthly for 22 months (March 2011-December 2012) between 0600 and 0700 GMT from each of the two sampling sites. The samples were obtained by towing a 0.5m diameter phytoplankton net (35µm mesh size and 0.25m² mouth surface area) from a non-motorized canoe through a distance of about 100m against the current from downstream to upstream. The phytoplankton samples were preserved with 1% Lugol solution in 50mL sampling bottles.

For enumeration of algal taxa, the description by Lund, Kipling and le Cren (1958) was adopted using a Carl Zeiss Axiovert S100 inverted microscope. The species identification was done following Needham and Needham (1962). The water samples were well shaken and aliquots of 15mL were transferred into counting chambers for microscopic study. Sedimentation was carried out in counting chambers with a settling time of four hours for every 1cm of water column of the sample, as described by Wetzel and Likens (1990). The phytoplankton densities were expressed as cells/m³ from the average count of three aliquots of 5mL each. For the filamentous algae, the average cell length was determined to be 4.8±0.34µm. Hence, for calculation of total cell counts, average cell length was assumed to be 5µm. Therefore, cell densities were estimated by dividing the determined cell count (C_{total}) through the filtered sample volume and expressed as cell counts/m³.

The plankton abundance of the four hydrological seasons were analysed using one way analysis of variance (ANOVA) of SPSS v. 16 on log (x+1) transformed data. Where there were significant differences (p<0.05) among means, the Duncan multiple range test was used to compare the treatment means.

The data on diversity of phytoplankton during each hydrological season were calculated with the data from plankton abundance by number using the PRIMER software version 6.1.6 (Clarke, & Gorley, 2006). Species diversity was estimated using the Shannon-Wiener

index (H^1) (Shannon & Weaver, 1963) from the density data (bits/ind.) and was expressed as:

$$H^1 = -\sum p_i \log p_i$$

where P_i is the proportion of individuals in the i^{th} species (Dahlberg, & Odum, 1970).

RESULTS

Phytoplankton composition, density and diversity: Table 1 shows a checklist of phytoplankton species during the pre- and post-impoundment periods while Fig. 1A and Fig. 1B shows the species composition and abundance in 2011 and 2012. In 2011, 35 species of phytoplankton belonging to four classes Bacillariophyceae (7.6%), Chlorophyceae (43%),

Cyanophyceae (48.6%) and Euglenophyceae (0.8%) were identified, while in 2012, 18 species belonging to three classes Bacillariophyceae (2.2%), Chlorophyceae (26.1%) and Cyanophyceae (71.7%) were identified (Fig. 2). Phytoplankton species diversity was lowest (0.8863) in the post-wet season and highest (1.2465) in the pre-wet season in 2011; while in 2012, diversity was lowest (0.9806) in the dry season, and highest (1.0583) in the post-wet season (Fig. 3).

Class Bacillariophyceae: Four species of Bacillariophyceae were identified in 2011 and two species in 2012 with *Synedra ulna* being the dominant species in both years. The mean seasonal variations in Bacillariophyceae during 2011 decreased from 171.7cells/m³ in

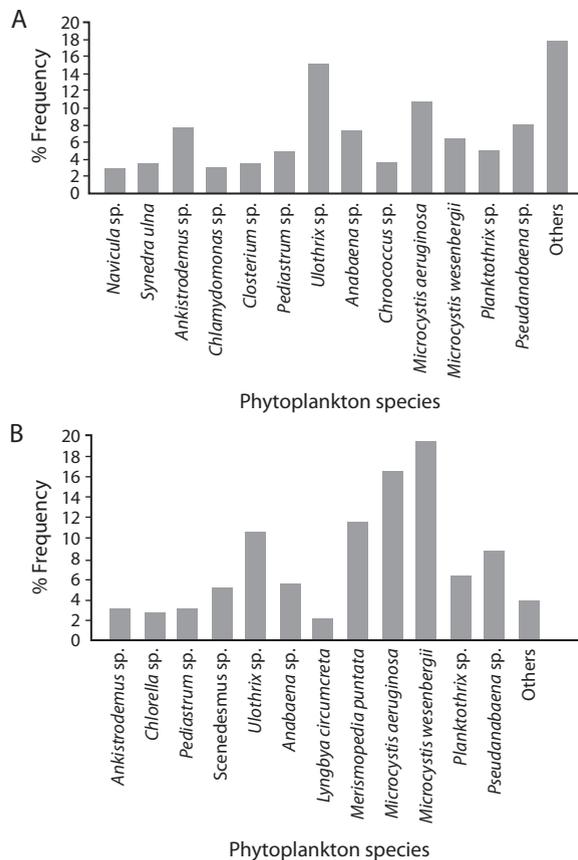


Fig. 1. A) Phytoplankton species composition in the Bui dam area of the Black Volta in 2011.

Fig. 1. B) Phytoplankton species composition in the Bui dam area of the Black Volta in 2012.



TABLE 1
Checklist of phytoplankton species during the pre- and post-impoundment periods

Class/species	Pre-impoundment (Mar-May 2011)	Immediate post-impoundment (Jun-Dec 2011)	Late post-impoundment (Jan-Dec 2012)
Bacillariophyceae			
<i>Gyrosigma</i> sp.	+	+	-
<i>Navicula</i> sp.	+	+	+
<i>Surirella</i> sp.	+	-	-
<i>Synedra ulna</i>	+	+	+
Chlorophyceae			
<i>Ankistrodesmus</i> sp.	+	+	+
<i>Carteria</i> sp.	+	-	-
<i>Chlamydomonas</i> sp.	+	-	+
<i>Chlorella</i> sp.	+	+	+
<i>Chlorogonium</i> sp.	+	-	-
<i>Closterium</i> sp.	+	-	-
<i>Coelastrum</i> sp.	+	+	-
<i>Cosmarium</i> sp.	+	-	-
<i>Dictyosphaerium</i> sp.	+	-	-
<i>Micrasterias</i> sp.	+	-	+
<i>Pediastrum</i> sp.	+	-	+
<i>Scenedesmus</i> sp.	+	+	+
<i>Schroederia</i> sp.	+	-	-
<i>Staurastrum</i> sp.	+	-	+
<i>Stigeoclonium</i> sp.	+	-	-
<i>Ulothrix</i> sp.	+	+	+
<i>Volvox</i> sp.	-	+	-
Cyanophyceae			
<i>Anabaena</i> sp.	+	+	+
<i>Chroococcus</i> sp.	+	-	-
<i>Coelosphaerium</i> sp.	+	-	-
<i>Lyngbya circumcreta</i>	+	+	+
<i>Merismopedia punctata</i>	-	+	+
<i>Microcystis aeruginosa</i>	+	+	+
<i>Microcystis wessenbergii</i>	-	+	+
<i>Oscillatoria</i> sp.	+	+	+
<i>Planktothrix</i> sp.	+	+	+
<i>Pseudoanabaena</i> sp.	+	+	+
<i>Rivularia</i> sp.	+	-	-
<i>Spirulina</i> sp.	+	-	-
Euglenophyceae			
<i>Euglena</i> sp.	+	-	-
<i>Phacus pyrum</i>	+	-	-

Key: + means present; - indicates absent.

the dry season to 1.7cells/m³ in the post-wet season with a significant difference (p<0.05) between the pre-wet and wet seasons (Table 2). Bacillariophyceae densities decreased from 27.3cells/m³ in the pre-wet season to 4.67cells/m³ in the wet season with significant

differences (p<0.05) between the pre-wet season and the three other hydrological seasons in 2012 (Table 3). There was no significant difference (p>0.05) between the upstream and downstream stations in 2011. There was however, a significant difference (p<0.05) between

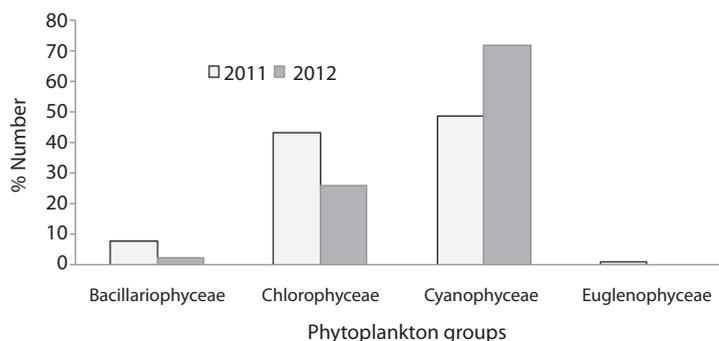


Fig. 2. Composition of phytoplankton groups in the Bui dam area of the Black Volta in 2011 and 2012.

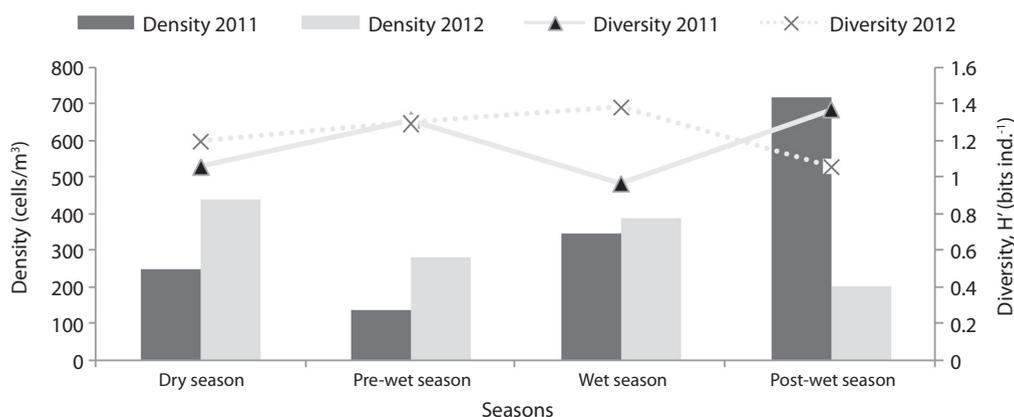


Fig. 3. Seasonal variations in density and diversity of phytoplankton in the Bui dam area of the Black Volta in 2011 and 2012.

TABLE 2
Seasonality of mean phytoplankton classes in 2011 (mean±standard error)

Taxa (cells/m ³)	Dry season	Pre-wet season	Wet season	Post-wet season
Bacillariophyceae	171.7 ^{ab} ±6.1	357.7 ^a ±15.0	8.0 ^b ±0.6	1.7 ^b ±0.2
Chlorophyceae	1 119.3 ^{ab} ±24.9	1 983.0 ^a ±45.7	8.0 ^c ±0.5	244.0 ^{bc} ±20.2
Cyanophyceae	194.0 ^a ±2.5	1 907.3 ^b ±10.9	274.3 ^a ±2.9	641.0 ^a ±29.0
Euglenophyceae	-	53.3±2.7	-	-
Total phytoplankton	1 414.3 ^{ab} ±30.5	3 906.0 ^a ±19.6	290.3 ^b ±12.5	886.7 ^{ab} ±48.8

Figs on the same row with different superscript letters are significantly different ($p < 0.05$) from one another.

the upstream and downstream stations in 2012. Additionally, mean densities of Bacillariophyceae decreased from 268cells/m³ during the pre-impoundment period to 11.08cells/m³ during the late post-impoundment period

with significant difference ($p < 0.05$) (Table 4). Hence, the abundance of phytoplankton species belonging to the class Bacillariophyceae changed following the impoundment of the Black Volta by the Bui dam.

TABLE 3
Seasonality of mean phytoplankton classes in 2012 (mean±standard error)

Taxa (cells/m ³)	Dry season	Pre-wet season	Wet season	Post-wet season
Bacillariophyceae	6.0 ^a ±0.4	27.3 ^a ±0.9	4.7 ^a ±0.7	6.3 ^a ±1.5
Chlorophyceae	194.7 ^{ab} ±8.2	246.0 ^a ±4.6	62.0 ^b ±3.5	56.7 ^b ±19.0
Cyanophyceae	696.0 ^a ±15.3	533.0 ^{ab} ±21.2	117.0 ^b ±7.4	94.7 ^b ±12.7
Total phytoplankton	897.7 ^a ±18.2	806.3 ^a ±26.3	183.7 ^b ±11.3	157.7 ^b ±32.6

Figs on the same row with different superscript letters are significantly different ($p < 0.05$) from one another.

TABLE 4
Mean phytoplankton classes during the pre- and post-impoundment periods (mean±standard error)

Taxa (cells/m ³)	Pre-impoundment (Mar-May 2011)	Immediate post-impoundment (June-Dec 2011)	Late post-impoundment (Jan-Dec 2012)	<i>P</i> value
Bacillariophyceae	268.0 ^a ±12.6	78.4 ^b ±7.4	11.1 ^b ±3.7	0.02*
Chlorophyceae	108.2 ^a ±46.8	518.4 ^b ±40.2	139.8 ^a ±33.1	0.09
Cyanophyceae	654.3 ^a ±39.3	962.4 ^a ±52.3	360.2 ^a ±97.7	0.35
Euglenophyceae	53.3±2.7	-	-	0.00*
Total phytoplankton	2 057.7 ^b ±91.2	1 559.3 ^a ±99.6	511.1 ^a ±26.1	0.22

*On the *P* values indicates significant differences ($p < 0.05$); Figs on the same row with different superscript letters are also significantly different ($p < 0.05$) from one another.

Class Chlorophyceae: A total of 17 and eight species of Chlorophyceae were identified in 2011 and 2012, respectively, with *Ulothrix* sp. as the most dominant. The mean seasonal variations in Chlorophyceae densities during 2011 decreased from 1983cells/m³ in the pre-wet season to 8cells/m³ in the wet season with a significant difference ($p < 0.05$). Chlorophyceae densities decreased from 246cells/m³ in the pre-wet season to 56.7cells/m³ in the post-wet season in 2012. There were significant differences ($p < 0.05$) between the pre-wet, wet and post-wet seasons. There was no significant difference ($p > 0.05$) between the upstream and downstream stations in 2011. There was however, a significant difference ($p < 0.05$) in the densities of species of Chlorophyceae between the upstream and downstream stations in 2012. Besides, mean densities of Chlorophyceae increased from 108.2cells/m³ during the pre-impoundment period to 518.43cells/m³ in the immediate post-impoundment period. There was a significant difference ($p < 0.05$)

between the pre-impoundment and late post-impoundment periods. Hence, the the abundance of phytoplankton species belonging to the class Chlorophyceae changed following the impoundment of the Black Volta by the Bui dam.

Class Cyanophyceae: A total of 12 species of Cyanophyceae were recorded and the dominant species was *Microcystis aeruginosa* in 2011. In 2012, eight species were recorded with *Microcystis wesenbergii* being dominant. The mean seasonal variations in 2011 increased from 194cells/m³ in the dry season to 1 907.3cells/m³ in the pre-wet season with a significant difference ($p < 0.05$) between the pre-wet season and the other 3 seasons. During 2012, densities also increased from 94.7cells/m³ during the post-wet season to 696cells/m³ in the dry season. There were significant differences ($p < 0.05$) between the dry and wet seasons. Cyanophyceae differed significantly ($p < 0.05$) between the upstream

and downstream stations in both 2011 and 2012. Also, Cyanophyceae densities decreased from 962.43cells/m³ in the immediate post-impoundment period to 360.17cells/m³ during the late post-impoundment period with no significant difference ($p>0.05$) among the periods. Hence, the abundance of phytoplankton species belonging to the class Cyanophyceae did not change following the impoundment of the Black Volta by the Bui dam.

Class Euglenophyceae: Two species of the class Euglenophyceae: *Euglena* sp. and *Phacus pyrum* were recorded in the 2011 sampling year. During 2012, no species was identified. The seasonal variations showed that species of the class Euglenophyceae were absent in the dry, wet and post-wet seasons, but present (53.3cells/m³) in the pre-wet season. This indicates that species of Euglenophyceae were only present during the pre-impoundment period of the study. Hence, the density of species of the class Euglenophyceae changed following the impoundment of the Black Volta by the Bui dam.

DISCUSSION

A total of 35 species of phytoplankton belonging to four classes were recorded during the study. The number of species per class were dominated by Chlorophyceae (17 species), Cyanophyceae (12 species), Bacillariophyceae (4 species), and Euglenophyceae (2 species). The distribution pattern of phytoplankton during the study showed that all the species, except *Euglena* sp. and *Phacus pyrum* (Euglenophyceae) were homogenously distributed in the four hydrological seasons. The lotic nature of the study area may be responsible for the relatively uniform seasonal distribution. Zab-bey, Sikoki and Edoghotu (2008) reported that in lotic ecosystems, continuous flows ensure near uniform distribution of organisms. The impoundment of the Black Volta may, however, be the principal factor responsible for the discontinuous seasonal distribution of *Euglena* sp. and *Phacus pyrum* observed in the study.

In all, 17 species of phytoplankton, including *Gyrosigma* sp., *Surirella* sp., *Carteria* sp., *Closterium* sp., *Chlorogonium* sp., *Coelastrum* sp., *Cosmarium* sp., *Volvox* sp., *Chroococcus* sp., *Coelosphaerium* sp., *Rivularia* sp. and *Spirulina* sp. were absent during the late post-impoundment period. Their absence indicates that they could possibly not be adaptable to the impoundment-induced environmental changes due to their preference for lotic water bodies. This therefore indicated that river impoundment had impact on the density and distribution of these species in the study area. Hence pre-impoundment studies should always be carried out when impounding a river to identify the phytoplankton species that may be altered as a result of river impoundment.

The results also showed that variations occurred between seasons and in some phytoplankton groups. The dry and pre-wet seasons had significantly higher mean phytoplankton abundance than the wet season during the sampling period. Phytoplankton abundance is associated with seasonal differences in flow. Densities of phytoplankton usually reach the peak in the dry season and diminish in the floods, unless otherwise influenced by temperature (Welcomme, 1985) or grazing effect of zooplankton (Rocha, Matsumura-Tundisi, Espindola, Roche, & Rietzler, 1999). In the Kafue River in Zambia, phytoplankton densities were found to be less during the floods and dense blooms occurring when the floods had receded (Carey, 1971). Seasonal variations in phytoplankton abundance with higher values in the dry season have also been reported by Erundu and Chinda (1991), Ogamba, Chinda, Ekweozor and Onwuteaka (2004) and Emmanuel and Onyema (2007).

The biotic indices of Shannon-Wiener were homogenously distributed in the four hydrological seasons of the two years. Minimal variations in the diversity of phytoplankton as reflected by Shannon-Wiener (H^1 (\log_{10})), may be attributed to uniform physical and chemical conditions (Ogamba et al., 2004). According to Williams (1964), species diversity indices often reflect the impact of pollution on aquatic

communities and pollution affects the distribution, standing crop and chlorophyll *a* concentration of phytoplankton (Barnes, 1980). The species in this study area were distributed fairly in all four seasons. This therefore suggests that at present pollution has minimal effect on the Black Volta near the Bui dam. Thus the phytoplankton can support a good fishery, because phytoplankton are the major producers and a food source for plankton consumers (Wehr, & Descy, 1998) and as well serve as the base of food chain that supports commercial fisheries (Conde, Bonita, Aubruit, Leon, & Pintos, 2007).

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RESUMEN

Variaciones estacionales en la diversidad del fitoplancton en la zona de la represa Bui del Volta Negro, Ghana, durante los períodos pre y post-embalse. El fitoplancton constituye uno de los productos primarios de los ecosistemas acuáticos y representa la base de la cadena alimentaria que mantiene las pesquerías comerciales de la mayoría de los cuerpos de agua. Hoy en día, hay una falta de información sobre el fitoplancton de la mayoría de los embalses en África. Este estudio se llevó a cabo para determinar la densidad y diversidad de las variaciones estacionales de las especies de fitoplancton en la zona de la represa Bui del Volta Negro, durante los periodos pre (2011) y post embalse (2012). Para ello, se adoptó un método de muestreo aleatorio estratificado de tres niveles para 22 meses. Las muestras de fitoplancton fueron obtenidas desde una canoa sin motor a través de 100m de distancia frente a la corriente de aguas abajo a aguas arriba del río, con una red de 0.5m de diámetro (35µm tamaño de malla y 0.25m² superficie de boca). En 2011, se identificaron 35 especies de fitoplancton pertenecientes a cuatro clases: Bacillariophyceae (7.6%), Chlorophyceae (43%), Cyanophyceae (48.6%) y Euglenophyceae (0.8%). En el muestreo de 2012 se observaron 18 especies pertenecientes a tres clases: Bacillariophyceae (2.2%), Chlorophyceae (26.1%) y Cyanophyceae (71.7%). Un total de 17 especies de

fitoplancton, incluidas *Gyrosigma* sp., *Surirella* sp., *Carteria* sp., *Chlosterium* sp., *Chlorogonium* sp., *Coelastrum* sp., *Cosmarium* sp., *Volvox* sp., *Chroococcus* sp., *Coelosphaerium* sp., *Rivularia* sp. y *Spirulina* sp., estuvieron ausentes durante el periodo post embalse. La media mensual de la abundancia total de fitoplancton disminuyó de junio (7 384 células/m³) hasta agosto (106 células/m³) 2011. Sin embargo en 2012, la media del fitoplancton total disminuyó desde febrero (1 237cells/m³) a agosto (4cells/m³). Los resultados también mostraron que las variaciones se produjeron entre las temporadas entre algunos grupos de fitoplancton. Las estaciones secas y húmedas tuvieron significativamente ($p<0.05$) mayor abundancia media de fitoplancton en la temporada de lluvias durante los 22 meses del periodo de muestreo. Los índices bióticos de Shannon-Wiener (H1) se distribuyeron de forma homogénea en las cuatro estaciones hidrológicas de los dos años. Los grupos de fitoplancton, Bacillariophyceae, Chlorophyceae, Euglenophyceae y fitoplancton total difirieron significativamente ($p<0.05$) entre los períodos pre y post-embalse. El fitoplancton total también fue significativamente ($p<0.05$) mayor en la estación aguas arriba que en la estación aguas abajo indicando el impacto del embalse sobre la ecología de aguas abajo. Por lo tanto, las estrategias de gestión de los ríos, debe ser ejecutada por un hidro-biólogo para disminuir el impacto de la represa en la ecología aguas abajo.

Palabras clave: embalse, chlorophyceae, cyanophyceae, densidad estacional, estación de aguas abajo.

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