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ORIGINAL RESEARCH ARTICLE

Phytoplankton and epipelic algal abundance in relation to bridge construction on Okpoka River in the Upper Bonny Estuary, Nigeria

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ABSTRACT

The objective of this study was to determine the impact of bridge construction on abundance and composition of phytoplankton and epipelic algae with respect to bridge construction on a section (ATC Okrika Axis) of Okpoka River, upper Bonny estuary in Nigeria. Phytoplankton and epipelic algae were collected in five replicates from six stations (UA - upstream, BA - bridge position, DA - downstream of bridge (reclaimed side) and (UC - upstream, BC - bridge position, DC downstream of bridge (vegetated side -mangrove) side of the river between January and March 2017. Thirty samples were collected per month with appropriate containers, preserved in 5% formalin-water mixture, taken to the laboratory and identified to the lowest possible taxonomic level. Ten species of phytoplankton (*Gyrosigma* spp., *Synedra* spp., *Navicula* spp., *Nitzschia* spp., *Thalassiothrix* spp., *Coscinodiscus* spp., *Fragillaria* spp., *Pleurosigma* spp., *Cyclotella* spp. and *Rhizosolenia* spp.) all belonging to the *Baccillariophyceae* (diatoms) were observed. Ten species (*Gyrosigma* spp., *Navicula* spp., *Synedra* spp., *Nitzschia* spp., *Thalassiothrix* spp., *Coscinodiscus* spp., *Fragillaria* spp., *Pleurosigma* spp., *Cymbella* spp. and *Cocconeis* spp.) of epipelic algae were also observed with the last two species in each group accounting for their differences. *Cyclotella* and *Rhizosolema* spp. were observed only on phytoplankton sampled and *Cymbella* and *Cocconeis* spp. were observed in epipelic algal samples suggesting minimal differences in composition. Analysis of variance indicated significant difference ($P<0.05$) in the abundance of both phytoplankton and epipelic algae between stations close to bridge construction compared to others sites farther away. The study therefore, concluded that activities of bridge construction across the Okpoka River impacted on the abundance and composition of phytoplankton and epipelic within the study area. Regular monitoring is recommended particularly after construction in order to detect recovery changes of these important aquatic algae that form the base of the food chain.

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INTRODUCTION

Bridge construction activities can have adverse impacts on water quality (Hedrick *et al*., 2010). These adverse impacts resulting from disruptions of ecosystem processes may take years to fully manifest themselves (Jackson, 2003). Phytoplanktons are single celled organisms which are the grasses of the sea and play a very vital role in the sea to form the basis of ocean productivity. Some of these phytoplankton but not all are in turn grazed on by zooplankton which is dominated by small crustaceans such as copepods, shrimps and their larvae (Portner and Farell, 2008). Bridge construction has the potential to disturb ecosystems through a variety of pathways (Sagar *et al*., 2004; Hedrick *et al*., 2010); differential sensitivities will lead to ecological winners and losers. Also a temporal and spatial shift in relationship between species e.g. shifts in terms of

phytoplankton and epipelic algae abundance relative to food availability in water (Giberto *et al*., 2004; Farkas *et al*., 2001). These may also lead to changes in nutrient cycling. There are evidence that indicates bridge construction to block the passage of fishes in water (Ruediger, 2001; Roni *et al*., 2002). The amount of phytoplankton in water column reflects the influence of a number of environmental factors and processes.

Epipelic algae are free living on submerged sediment (Rennie and Jackson, 2005). Epipelic algae serve as available food base for many invertebrates and waterfowl (Kara and Sahin, 2000). About 70% of the invertebrate production was supported by attached algae (Borowitzka *et al*., 1990). Phytoplankton and Epipelic algae are regarded as excellent indicators of environmental conditions of water habitats (Angermeier and Rosenberger 2005; Traunspurger and Drew, 1996; Harding *et al*., 2002) and have been introduced for biomonitoring studies. The Okpoka creek is dominated by Nypa palm (*Nypa fruticans*), Red mangrove (*Rhizophora racemosa*), white mangrove (*Avicennia nitida*) and other species of water ferns.

Development projects such as bridge construction could impact on the ecology of aquatic systems; hence the aim of this study is to assess the effect of anthropogenic activity on the abundance and composition of algae on a section of the Okpoka River in the Upper Bonny Estuary, Nigeria. This shall enable distinction in composition and abundance between phytoplankton (water column) and epipelic algae (surface sediment) in relation to a specific activity that impacts on them simultaneously.

MATERIALS AND METHODS

Study site

The study site is a section (ATC Okrika Axis) of the Okpoka River and a major bridge construction is on-going in the Okpoka Creek. The coordinates of the sampled sites are (BA: E 007^0 04' 36.1, N 04^0 44' 22; BC: E 007^0 04' 27.3, N 04. 44. 22.06; DA: E 007^0 04' 37.2, N 04^0 44' 17.6; DC: E 007^0 04' 25.3, N 04^0 44' 18.5; UA: E 007^0 04' 35.3, N 04^0 44' 28.0; E 007^0 04' 37.2, N 04^0 44 24.0). It is a tidal river that supports major economic activities like fishing and marine transportation. Development needs has attracted a bridge construction project and recently oil bunkering activities has been observed in the area. One side of the river still has mangrove vegetation while the other side had been reclaimed for expansion of residential area. Vegetations on one side include Nypa palm (*Nypa fruticans*), white mangrove (*Avicennia nitida*) red mangrove (*Rhozophora racemosa*) and other water ferns. Domestic wastes dumps were also observed on the bank of the residential side of the river. Figure 1 shows study location and sampled points. UA, BA, DA represented upstream, bridge position and downstream on the reclaimed side of the while UC, BC, DC has the same positions but on the vegetated (mangrove vegetation) side of the river.

Sample collection and analysis

Five replicates samples were collected randomly from each station for six stations making a total of ninety samples at monthly intervals for three (3) months (January to March 2017). Sediment samples were collected with an Ekman grab (15 cm × 15 cm) and epipelic algae carefully scraped from the surface of sediments into sterile bottles. Samples were preserved in 5% formalin-sea water mixture and immediately taken to the laboratory for analysis. Epipelic algae were analyzed according to Ogamba (2003; Wickstead, 1976).

Phytoplankton samples were collected directly with one liter contain open mouth containers and also preserved in 5% formalin and taken to the laboratory for analysis. The preserved phytoplankton samples (APHA, 2012) was allowed to stand for at least a minimum of 24 hours in the laboratory before decanting the supernatant. The decanting was done carefully until a 50ml concentration sample was left. The concentrated sample containing the organism (phytoplankton) was thoroughly shaken and a one ml (1 ml) of sub-sample was collected using a stamped pipette into a Bogoros counting chamber (Wickstead, 1976), identification and enumeration was carried out under a light microscope.

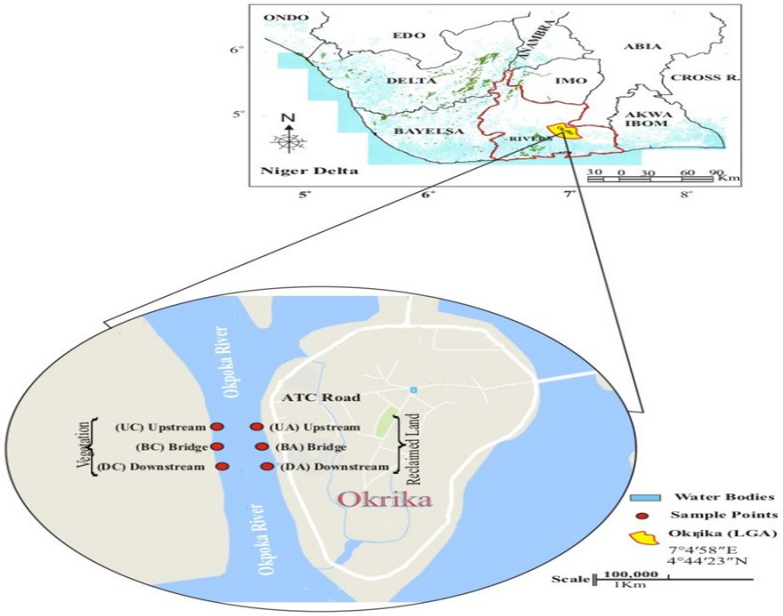

Figure 1. *Study location showing sampled sites at Okpoka River in the Upper Bonny Estuary, Nigeria.*

Statistical analysis

The software package MINITAB was used for analysis of variance in terms of the abundance of organisms with respect to the stations examined. This was important in order to detect statistically significant variations in organism abundance across the stations sampled.

RESULTS AND DISCUSSION

Composition and abundance of phytoplankton

Table 1 presents checklist of phytoplankton observed during the study while Figure 2 presents the variations in density of organisms (± standard error bars) across the stations examined. Phytoplankton composition and abundance across all stations (UA, UC, BA, BC, DA, and DC) had only the Bacillariophyceae with ten species (*Gyrosigma* spp., *Synedra* spp., *Navicula* spp., *Nitzschia* spp., *Coscinodicus* spp., *Cyclotella* spp., *Pleurosigma* spp., *Thalassiothrix* spp., *Fragillaria* spp., *Rhizosolenia* spp.). Six of this species (*Gyrosigma* spp., *Synedra* spp., *Navicula* spp, *Nitzschia* spp., *Coscinodicus* spp. and *Thalassiothrix* spp.) were observed in all the stations (UA,UC,BA,BC,DA,DC) while *Cyclotella* spp and *Rhzosolenia* spp. were obtained only at Station (BC). *Gyrosigma* spp. were obtained in all stations with density ranging from 16 – 190 cells/ml with the lowest and highest observed at (UC) and DC, respectively. *Synedra* spp. were also observed in all stations with density values in the range of 10 – 111 cells/ml with the highest seen at station UC and the lowest at station DA. *Navicula* spp. also observed in all stations had most density (221 cells/ml) at station DC and least density (7 cells/ml) at station UC. The highest density of *Thalassiothrix* spp. (22 cells/ml) was obtained at station UC and the least (2 cells/ml) was recorded at station BC. *Cyclotella* spp. was recorded only in stations UA, DA and DC with density ranging from 3 – 19 cells/ml. The highest (19 cells/ml) values was obtained at station UA and the least (3 cells/ml) values was noticed at stations DA and DC. *Coscinodicus* spp. was obtained in all the Stations with the highest (109 cells/ml) density obtained at station BA and the least (10 cells/ml) at Station UC. However, *Pleurosigma* spp. were seen in only three stations (UC,BA and ,DA) with the highest (16 cells/ml) at station DA and the least (1 cell/ml) obtained at station UC. *Fragillaria* spp. were obtained in stations UA, UC ,BA ,BC and ,DA but was not found in station DC. Cell density range from 7 – 28 cells/ml with the highest (28 cells/ml) recorded at station UA and the least (7cells/ml) reported at station BC.

Abundance and composition of epipelic algae

Table 2 presents a checklist of epipelic algae observed during the study while Figure 3 presents the density of organisms with standard error bars across the stations examined. The Bacillariophyceae were also the only epipelic algae observed in all stations during the study. The abundance of the epipelic algae were generally more than the phytoplankton. *Gyrosigma* spp. were obtained in all Stations (UA ,UC, BA, BC, DA , DC) with number of cells per ml ranging from 500 – 1230 Cells/ml at stations BA and UC respectively while *Cocconeis* spp. was noticed only at one station with a density of 0.2 cells/ml. *Cymbella* spp. was observed only at two stations (DA and DC) with not more than 5 cell/ml but *Pleurosigma* spp. were obtained in all stations with value ranges of 61 – 1267 cells/ml at stations UC and UA respectively. *Thalassiothrix* spp. were observed at 5 Stations (UA , BA, BC, DA , DC) with density values that range from 0 – 107 cells/ml .The highest (107 cells/ml) was obtained at station UA and the lowest (0 cell/ml) was noticed at station UC. *Navicula spp* and *Nitzschia* spp. were recorded in all stations with density ranges of 125 – 5301 cells/ml at stations UC and DC and 117 – 357 cells/ml at stations UC and DA, respectively.

Analysis of variance indicated that there was significant difference in the abundance of phytoplankton (*Gyrosigma* spp., *Navicula* spp., *Nitzschia* spp., *Coscinodiscus* spp. *Cyclotella* spp. *Pleurosigma* spp.) as well as epipelic alagae (*Synedra* spp., *Navicula* spp., *Nitzschia* spp., *Coscinodiscus* spp., *Pleurosigma* spp., *Thalassiothrix* spp., *Fragillaria* spp.) across the stations examined. Such difference was attributed to the impact of the bridge construction activities in relation to other stations farther away from the bridge area.

Comparison of phytoplankton and epipelic algae species indicated that eight species (*Gyrosigma* spp., *Synedra* spp., *Navicula* spp., *Nitzschia* spp., *Coscinodicus* spp., *Pleurosigma* spp., *Thalassiothrix* spp., *Fragillaria* spp.,) were common to both groups whereas two species *Cyclotella* spp. and *Rhizosolema* spp. were only present in the phytoplankton and *Cymbella* spp. and *Cocconeis* spp. were observed only in Epipelic algae.

Table 1. Check list of phytoplankton observed in Okpoka River in the Upper Bonny Estuary, Nigeria.

Species	Stations					
	UA	UC	BA	BC	DA	DC
Gyrosigma spp.	+	+	+	+	+	+
Synedra spp.	+	+	+	+	+	+
Coscinodicus spp.	+	+	+	+	+	+
Cyclotella spp.	-	-	_	+	_	_
Navicula spp.	+	+	+	+	+	+
Nitzschia spp.	+	+	+	+	+	+
Fragilaria spp.	+	-	+	+	+	+
Rhizosolenia spp.	-	-	-	+	-	-
Thalassiothrix spp.	+	+	+	+	+	+
Pleurosigma spp.	+	+	-	+	+	+

Table 2. Check list of epipelic algae observed in Okpoka River in the Upper Bonny Estuary, Nigeria.

Species	Stations					
	UA	UC	BA	BC	DA	DC
Gyrosigma spp.	+	+	+	+	+	+
Synedra spp.	+	+	+	+	+	+
Coscinodicus spp.	+	+	+	+	+	+
Cymbella spp.	-	-	_	-	+	-
Navicula spp.	+	+	+	+	+	+
Nitzschia spp.	+	+	+	+	+	+
Fragilaria spp.	-	+	+	-	+	+
Cocconeis spp.	-	-	-	-	+	-
Thalassiothrix spp.	+	+	+	+	+	+
Pleurosigma spp.	+	+	+	+	+	+

Table 3. Composition of phytoplankton and epipelic algae and p-value of analysis of variance.

Species	Phytoplankton	Epipelic algae	p-value (phytoplankton)	p-value (Epipelic Alagae)
Gyrosigma	+	+	0.01*	0.11
Synedra	+	+	0.69	0.01*
Navicula	+	+	0.01*	0.01*
Nitzschia	+	+	0.01*	0.01*
Coscinodiscus	+	+	0.01*	0.01*
Cyclotella	+	-	0.01*	-
Pleurosigma	+	+	0.01*	0.01*
Thalassiothrix	+	+	0.06	0.04*
Fragillaria	+	+	0.15	0.01*
Rhizosolema	+	-	0.53	-
Cymbella	-	+	-	0.36
Cocconeis	-	+	-	0.43

Key: * Significant difference (*P*<0.05)

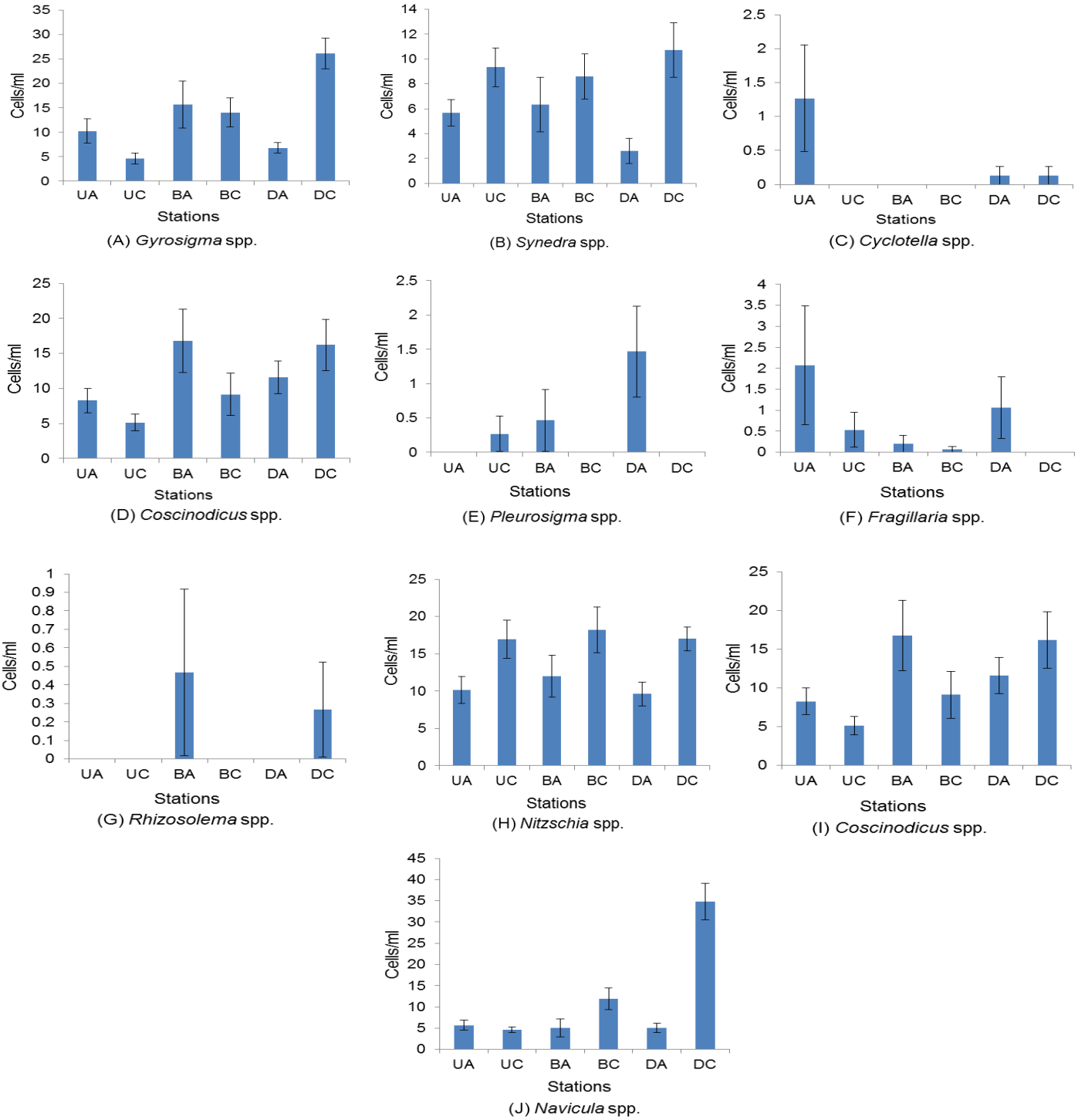

Figure 2 (A-J). *Spatial variation in mean density of phytoplankton (± Standard Error) across study sites at Okpoka River in the Upper Bonny Estuary, Nigeria.*

The predominance of *Bacillariophyceae* in Niger Delta waters is not only seen in Phytoplankton communities but also in Epipelic algal communities (Chindah and Nduaguibe, 2003; Nwankwo *et al.*, 2003; Chindah, 2004). Species found were almost in all stations indicating a widespread occurrence of *Bacillariophyceae* in Okpoka River. Townsend *et al.* (1992a, 1994b), in his studies investigated that the dominance of *Bacillariophyceae* is a common feature of the open euthropic water systems. Irrespective of the environmental influence, the diatoms (*Bacillariophyceae)* dominated the entire community of phytoplankton and epipelic algae with *Nitzchia* spp., *Coscinodiscus* spp., *Navicula* spp., *Synedra* spp., *Gyrosigma* spp., *Pleurosigma* spp., *Thalassiothrix* spp. and *Fragillaria* spp. being the most abundant consequently, the distribution pattern for the stations differs in their diversity of numbers.

The community of phytoplankton and epipelic algae plays an important role as primary producers in aquatic ecosystems. Their species have been extensively used as an indication of environmental change such as eutrophication, acidification, salinification (Polge *et al.*, 2010). Low concentration of nutrients generally has significant implication for phytoplankton composition (Kadiri, 2000). The dominance of phytoplankton and epipelic algae in this study area is in agreement with research made by Nwadiaro (1990) in Canon creek system of the Niger Delta, Chindah and Pudo (1991) in Bonny River, Erondu and Chindah (1991) in the New Calabar River. The presence of elevated value of *bacillariophyceae* indicated bad quality of water (Verma, 2002) hence *bacillariophyceae* are regarded as a good indicator of water pollution (Prasad and Singh, 1996). According to the reports of Nair *et al.* (1981), Mishra *et al.* (2008), Manoj and Bhavesh (2008), Murugan (2008), that 8 elevated number of *Nitzschia* spp., *Navicula* spp., *Fragilaria* spp., *Synedra spp*,and *Cocconeis* spp. shows the presence of water pollutants.

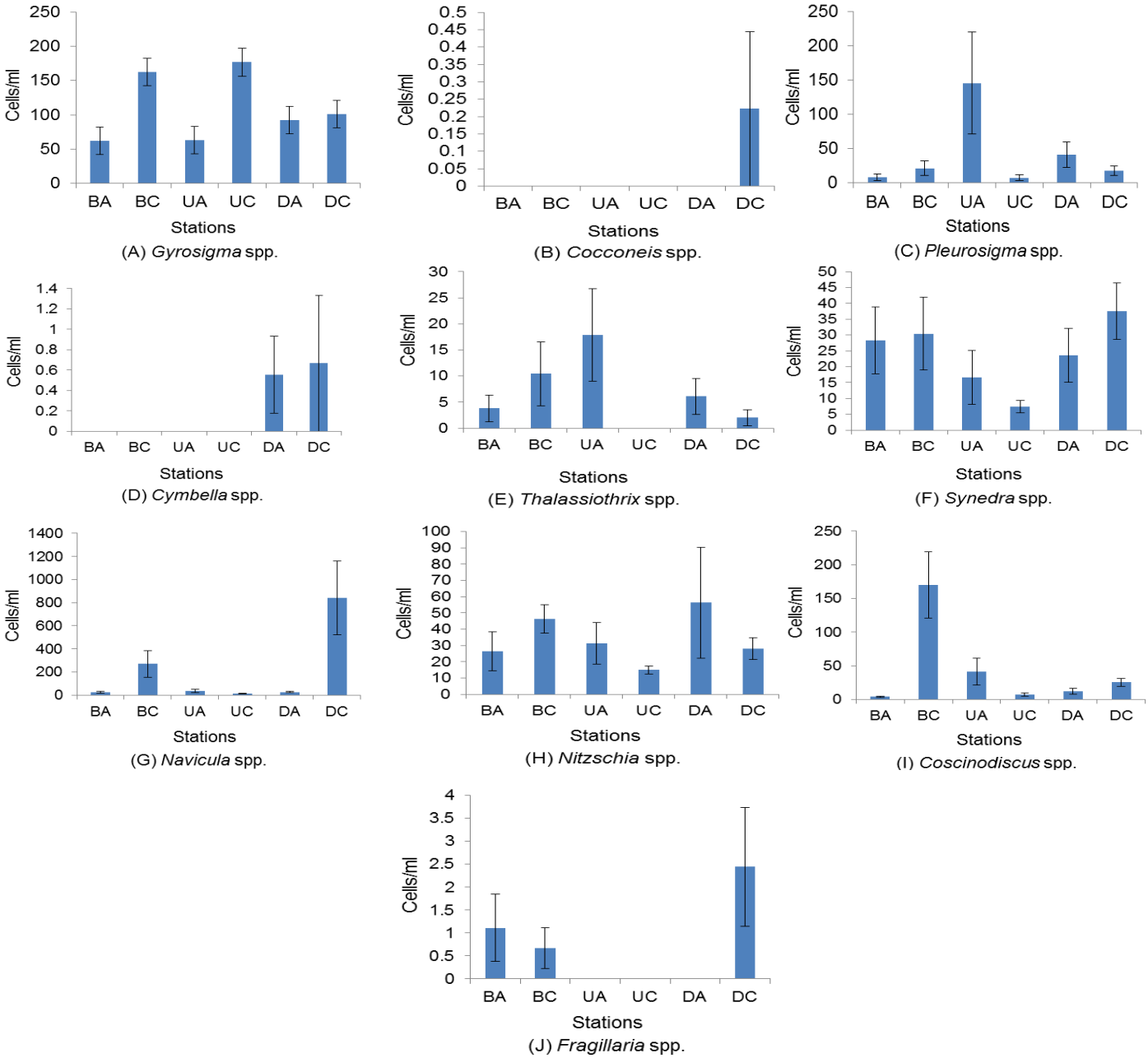

Figure 3 (A-J). *Density of organisms with standard error bars across the stations examined in Okpoka River in the Upper Bonny Estuary, Nigeria.*

Conclusion

Examination of the study are indicated the presence of phytoplankton and epipelic algae. This was however, singly dominated by the Bacillariophyceae in the water column and surface sediment. Common species of this family observed included *Nitzchia* spp., *Coscinodiscus* spp., *Navicula* spp., *Synedra* spp., *Gyrosigma* spp., *Pleurosigma* spp., *Thalassiothrix* spp. and *Fragillaria* spp. The density of phytoplankton (*Gyrosigma* spp.: 16 – 190 cells/ml; *Synedra* spp.: 10 – 111 cells/ml; *Navicula* spp.: 7 -221 cells/ml; *Thalassiothrix* spp.: 2 - 22 cells/ml; *Cyclotella* spp. 3 – 19 cells/ml; *Coscinodicus* spp. 10 - 109 cells/ml) observed during the study was generally less compared to the density of epipelic alagae (*Gyrosigma* spp.: 500 – 1230 Cells/ml; *Cocconeis* spp.: 0.2 cells/ml; *Cymbella* spp. 0 - 5 cell/ml; *Pleurosigma* spp.: 61 – 1267 cells/ml; *Thalassiothrix* spp.: 0 – 107 cells/ml; *Navicula* spp. 125 – 5301 cells/ml; *Nitzschia* spp.:117 – 357 cells/ml). Comparison of the result show higher abundance and composition of the phytoplankton and epipelic algae on the mangrove vegetation side of the study area thane the reclaimed side. Again, composition and abundance of these organisms were lower around the bridge construction area (BC and UC) compared to stations further away. This implies the impact of bridge construction activities on the phytoplankton and epipelic algae of the study area.

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