An Incidence of Substratum Discolouration in a Tropical West African Lagoon.

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Abstract

A greenish discolouration of the lagoon floor at the Bayeku area of the Lagos lagoon was observed in January 2006. We report here an investigation of the area between December, 2005 and Feburary, 2006 as part of a larger study. A total of 19 species from 13 genera were reported. *Oscillatoria tenuis* (95,800 trichomes per ml) was implicated as the causative organism for the substratum discolouration. Increased insolation, especially reaching the lagoon floor, low salinity, absence of flood conditions, suitable sediment type (fine – medium sand) and high nutrient (PO_4 - P > 0.24 mg/L; NO_3 – N > 4.40mg/L) levels possibly encouraged the algal proliferation and subsequent substratum discoloration. It is suggested that improving water quality indices and salinity after January caused the disappearance of the discolouration on the substratum. [Report and Opinion. 2009;1(2):17-25]. (ISSN: 1553-9873).

Keywords: algae, water quality indices, substratum.

INTRODUCTION.

Coastal algal blooms respond to nutrient load from anthropogenic sources (Lee, 1999; Onyema, 2007). South-western Nigeria is endowed with an intricate network of rivers, creeks and lagoons, that serve as conduits transferring highly nutrified waters from hinterland to coastal areas. Bloom conditions have been reported in some of these waters (Nwankwo *et al.*, 2003a; Nwankwo *et al.*, 2008). Blooms of *Microcystis aureginosa*, *M. flos-aquae* and *M. wesenbergii* were reported in the Lagos lagoon (Nwankwo, 1993), Ogun river at Iju (Nwankwo, 1993) causing bluish colouration, anoxia, odour, impacting taste to the water (Nwankwo *et al*., 2003a) and kuramo lagoon (Nwankwo *et al.*, 2008). Blooms of *Trichodesmium thiebautii* have also been reported off the Lagos coast (Nwankwo, 1993) during thermocline conditions and more recently a bloom of *Bellerochea malleus* that caused brownish discolouration off the Light house beach, Lagos (Nwankwo *et al.*, 2004) was documented. Blooms of *Anabaena flos-aquae, A. spiroides* (cyanobacteria), *Örataulina bergoni*, *Chaetoceros convolutus, Coscinodiscus centralis* (diatoms) and *Ceratium furca, C. fusus, C. tripos* and *Noctiluca scntillans* (dinoflagellates) are known to induce harmful effects in waters of south-western Nigeria (Nwankwo, 1993; Nwankwo *et al.*, 2003a, b, Onyema, 2008). There is at present a report of substratum discolouration in the Lagos lagoon system (Onyema and Nwankwo, 2006) implicating *Beggiatoa alba* and *Oscillatoria* spp as causative species.

Between December, 2005 and Feburary, 2006, a greenish discolouration of the substratum at Bayeku was observed and thoroughly investigated. We report here the composition of the organisms before, during the bloom period and after the collapse. Water quality indices before, during and after the substratum discolouration were also estimated and investigated. This report is part of a larger study that was already ongoing at the time of the occurrence.

MATERIALS AND METHODS.

Description of study area.

The Lagos lagoon opens into the sea via the Lagos habour all through the year. The tidal height is low (<1.5m) and the tidal exchange weak. It is shallow (<2m) and connected to the Epe lagoon to the east. The area investigated was (Fig 1) the Bayeku area of the Lagos lagoon (Latitudes 6^0 32^lN and 6^0 31^lN and Longitudes 3^0 31^lE and 3^0 32^lE). A greenish, slimy covering of suspected algae on the lagoon floor was observed for the very first time in this area. Nutrient rich water is known to flow from eutrophic creeks and creeklets systems in the area. Furthermore, poor sewerage systems are the common state of the rural dwellers of the immediate area. Hence direct dumping of domestic wastes is carried out in the closet water body.

Collection of samples

Water samples for determining water quality characteristics were collected at the site before substratum sample collection. The boat was anchored throughout sample collections. Water samples were collected in 1L plastic bottles with screw cap from 0.5m depth from the water surface. This was labeled and transported to the laboratory for chemical analysis.

Substratum samples (top 5cm) were collected within a $5cm^2$ quadrat carefully placed on the greenish material / lagoon floor. A spatula was gently used underwater to scrape the topmost part. After carefully scooping up the greenish scum, it was gently spooned into a plastic bag while still underwater. Duplicate samples were collected on each occasion. Out of water and in the boat, samples were transferred to 75cl screw capped plastic containers. Samples were fixed with formalin (4% unbuffered) and labeled appropriately on the field before onward transportation to the laboratory. This process was carried out on each sampling occasion.

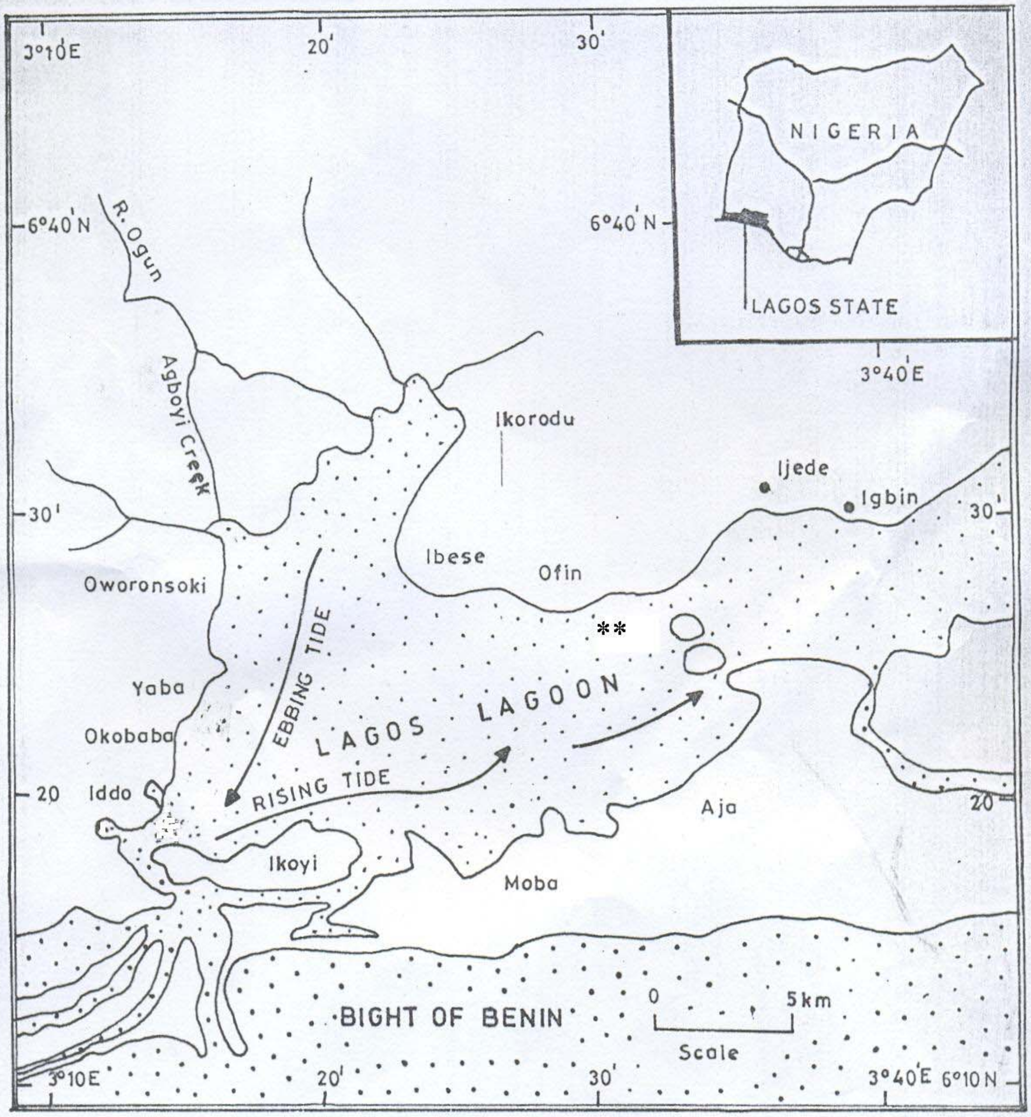

Fig. 1 : Lagos lagoon showing sampling site **

Physico-chemical analysis

Air and surface water temperatures were measured in-situ using a mercury thermometer while water depth was estimated with a calibrated pole. Total dissolved solids was determined by evaporating 100ml aliquot at 105^{o}C and total suspended solids estimated by filtering 100ml of sample through a pre-weighed filter paper, dried to constant weight and reweigh. Conductivity was measured using the HANNA instrument while salinity was determined using the silver-nitrate chromate method. The surface water pH was determined with a Griffin pH meter (Model 80) while dissolved oxygen was measured using a Griffin oxygen meter (Model 40). Biological and chemical oxygen demands were measured using methods described in APHA (1998) for water analysis. Calorimetric methods using a Lovibond Nesslerier were adopted for the direct determination of phosphate-phosphorus and nitrate-nitrogen values while sulphate levels were measured using the gravimetric method. Calcium and magnesium ions were determined using a 400 single channel, low flame photometer. Concentrations of copper, iron and zinc were determined with an atomic absorption spectrophotometer (A.A.S.) Uni cam 99model.

Biological Analyses

In the laboratory, the drop count microscope analysis method described by Onyema (2007) was used to estimate the substratum algal flora. Microscope analysis was carried out on samples within 48hours of collection. Identification materials were used to assist and confirm identification of species (Smith 1950; Hendey, 1958, 1964; Desikachary, 1959; Wimpenny, 1966; Patrick and Reimer, 1966, 1975; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 2004a; Bettrons and Castrejon, 1999; Siver, 2003; Rosowski, 2003).

RESULTS.

Physico-chemical.

Air (31 - 32 ^{o}C) and water (30 - 31 ^{o}C) temperatures were high through out the sampling period while the sampling depth was averagely 1.31m. The water remained slightly alkaline throughout the study (7.01 – 7.10). The total dissolved solids (20 - 33 mg/L), salinity (2.30 - 20.60 $^{o}/_{oo}$), chloride content (770.0 – 6930 mg/L), conductivity (2335 – 12,500 µS/cm), acidity (3.0 - 8.8 mg/L), alkalinity (28.5 - 100.3 mg/L), total hardness (562.5 - 4687.0 mg/L), sulphate (6.1 – 60 mg/L) and cation content (Calcium 111- 500, Magnesium 35.6- 859 mg/L) increased as the dry season progressed, while there was a corresponding decrease in total suspended solids (1590 – 8260 mg/L), nitrate (2.5 - 4.8 mg/L), biological (5 - 11mg/L) and chemical oxygen demands (10 – 49 mg/L) and heavy metals levels (Iron 0.14 - 0.35, Zinc 0.003 - 0.006mg/L) (Table 1).

With regard to the algae, just one species each was recorded for December 2005 (*Microcystis aureginosa* Kutzing) and January 2006 (*Oscillatoria tenuis* Agardh), However, 17 species were recorded in February (Table 2). Although, total biomass in terms of cell numbers was high in January (95,800 trichomes per ml) it was for a sole species. This organism (*Oscillatoria tenuis* Agardh) is the implicated microalgae responsible for the greenish discolouration of the lagoon floor at Bayeku. Furthermore, February recorded 3 cyanobacteria, 8 centric diatoms and 6 pennate diatoms species. *Actinophycus splendens* Ralfs and *Biddulphia laevis* Ehrenberg were important diatoms and *Oscillatoria limnosa* Agardh for the cyanobacteria in terms of numbers in February.

Table 1: Monthly variation in water quality characteristics at Bayeku area of the Lagos lagoon (Dec., 2005 – Feb., 2006).

Physico-chemical parameters	Dec., 2005	Jan., 2006	Feb., 2006
Air temperature (^oC)	32	31	31
Water temperature (^oC)	30	31	30
Depth (m)	1.42	1.24	1.41
Total Suspended Solids (mg/L)	33	27	20
Total dissolved Solids (mg/L)	1590	5120	8260
Salinity ($^o/_{oo}$)	2.30	9.20	20.60
Chloride (mg/L)	770.0	3086.0	6930
Conductivity (µS/cm)	2335	7877	12500
pH	7.05	7.01	7.10
Acidity (mg/L)	3.0	8.8	8.1
Alkalinity (mg/L)	28.5	30.4	100.3
Total Hardness (mg/L)	562.5	360.0	4687.0
Nitrate- Nitrogen (mg/L)	4.4	4.8	2.5
Sulphate (mg/L)	6.1	10.8	60
Phosphate- Phosporus (mg/L)	0.24	0.26	0.04
Silica (SiO_2 mg/L)	1.9	2.6	2.1
Dissolved Oxygen (mg/L)	5.5	4.2	4.3
Biological Oxygen Demand (mg/L)	11	9	5
Chemical Oxygen Demand (mg/L)	49	27	10
Calcium (mg/L)	165	111	500
Magnesium (mg/L)	35.6	50	859
Copper (mg/L)	0.002	0.002	0.002
Iron (mg/L)	0.35	0.22	0.14
Zinc (mg/L)	0.005	0.006	0.003

Table 2: Substratum algal composition (before, during and post bloom) at Bayeku (per ml).

Algal Taxa	Dec., 2005	(Bloom) Jan., 2006	Feb., 2006
Class – Cyanophyceae			
Order I – Chrooccocales			
Microcystis aureginosa Kutzing	170	-	-
Order II – Hormogonales			
Lyngbya limnetica Lemm	-	-	5
Oscillatoria curviceps C.A. Agardh	-	-	10
Oscillatoria limnosa Agardh	-	-	60
Oscillatoria tenuis Agardh	-	95,800	-
Class – Bacillariophyta			
Order I - Centrales			
Actinophycus splendens (Sch adbolt) Ralfs	-	-	205
Biddulphia laevis Ehrenberg	-	-	125
Coscinodiscus centralis Ehrenberg	-	-	10
Coscinodiscus eccentricus Ehrenberg	-	-	10
Coscinodiscus radiatus Ehrenberg	-	-	5
Cyclotella meneghiniana Kutzing	-	-	15
Melosira moniliformis (O.F. Muller) Agardh	-	-	10
Melosira nummuloides Agardh	-	-	35
Order II – Pennales			
Cymbella affinis Kutzing	-	-	15
Navicula mutica Kutzing	-	-	5
Nitzschia palea (Kutzing) Wm Smith	-	-	5
Pleurosigma angulatum (Quekett) Wm Smith	-	-	55
Pleurosigma elongatum Wm Smith	-	-	15
Synedra crystallina Kutzing	-	-	20
Number of species (S)	**1**	**1**	**17**
Species abundance (N)	**170**	**95,800**	**605**

DISCUSSION.

The water quality status at the site ranged between low and high brackish water conditions. Low brackish condition (S=2.30‰) was experienced in December while high brackish condition (>9.20‰) reflected the dry months. As the rain ceased, turbidity reduced while transparency increased. Furthermore, insolation increased probably reaching the lagoon floor. This coupled with high nutrient levels (PO_3^{2-} > 0.24mg/L, NO_3^- > 4.4mg/L, SO_4^{2-} >6.1mg/L), low brackish condition (<9.2$^0/_{00}$) and low depth (<1.42m), favorable sediment type (fine – medium sand) and absence of flood conditions probably encouraged the proliferation of the epipelic algal population in January. According to Valangdiham (1982), *Oscillatoria tenius,* the causative cyanobacterium, in the substratum discolouration, is a saprobiont which can exist either as plankton or as an attached form. Palmer (1969) reported that *Oscillatoria tenuis* is the second most tolerant *Oscillatoria* species to organically induced stress. It's important to note that both sole species in December and January are known pollution tolerant cyanobacteria forms for the region (Nwankwo, 2004b).

Importantly, the highest level of nitrate (4.8 mg/L) recorded for this study was in January at the time of the greenish occurrence.

Oscillatoria spp are reported in literature to have wide tolerance limits to pH, salts and organically enriched environments (Valangdiham, 1982; Lee, 1999; Nwankwo, 2004b; Onyema, 2008). In Nigeria, Onyema *et al*., (2003) has reported *Oscillatoria tenius* in organically polluted parts of Lagos lagoon. Similarly, Chindah and Pudo (1991) have reported *Oscillatoria tenius* from the Bonny river associated with oil related effluent. According to Valangdiham (1982) *Oscillatoria* species are heavily favoured in organically nutrified waters. The existence of high BOD levels in excess of 9mg/L at this site may be pointer to the probably stressed water quality status. According to Hynes (1960), BOD above 8.0mg/L may indicate severe organic pollution.

The disappearance of the bloom in February may be associated with increased salinity ($\geq 20.6^{0}/_{00}$) and reduced nutrient load (PO_4 – P 0.04mg/L; NO_3-N = 2.05mg/L). Onyema and Nwankwo (2006) reported a high abundance of epipelic algal forms in the dry months at some organically polluted sites of an estuarine creek in Lagos.

This investigation highlights the bane of increasing levels of pollutants from anthropogenic sources in the Lagos lagoon and the role of algal indicators in capturing changes in water quality.

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