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Diatoms as Indicator of Pollution in *Awon* Reservior, Oyo Town, Nigeria

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Abstract: Diatoms as indicator of pollution in *Awon* reservoir were studied for two years. Two set of water samples were collected, one for physico-chemical characteristics analysis and the other set for biological analysis. *Pinnularia lata*, *P. mesolepta*, *Navicula rhychocephala*, *Aulacoseira granulata* and *Amphora* were the most prominent diatoms that served as good indicators of pollution. These organisms predominated during the raining season than during the dry season. Weather conditions ere majorly responsible for the physical and chemical changes in thee reservoir. The wet season of the experiment was characterized by the influx of flood water and the consequent mixing of the reservoir water with attendant increase in transparency and nutrient levels. The dry season of the experiment was characterized by high conductivity and high silica level. The study suggests that the presence of any of the predominated organisms in the water is an indication of water pollution.

Key words: Dry season conductivity, diatoms, abiotic factors, macrophytes

INTRODUCTION

Diatoms are the most important phytoplankton group contributing substantially to aquatic productivity of oligo-trophic systems. Anadu *et al*. (1990) and Khan *et al*. (1983) demonstrated that water quality affects species composition and abundance. The most common abiotic parameters associated with primary production in lakes and reservoirs are phosphate and nitrate contents which are associated with algal blooms, variations in chlorophyll content and phytoplankton dynamics. Other important abiotic factors in lakes and reservoir productivity studies include dissolved oxygen, alkalinity, carbondioxide, biochemical oxygen demand and dissolved organic matters (Anadu *et al*., 1990). Ecology of diatoms had been studied (Cox, 1975; Dakshini and Soni, 1982; Lowe, 1974; Patrick, 1964; Patrick, 1973).

In Nigeria, the dominance of diatoms in waters has been documented (Amuda, 1990; Akinyemi, 2000; Imevbore, 1971; Egborge, 1979) and in the coastal waters of the south western Nigeria (Nwankwo, 1986). Presently, there is little or no information on diatom community of *Awon* reservoir which is a popular reservoir responsible for a significant provision of drinkable water for the human population in the local community.

MATERIALS AND METHODS

Description of the Study Area

The reservoir (Fig. 1) lies between latitude 7°75'N and longitude 4°E. It was built in 1962. The purpose of the reservoir is to supply portable water to the people of Oyo community and its environs. The macrophyte by the reservoir bank comprise mainly of *Pistia stratiotes* and few species of *Ipomea*.

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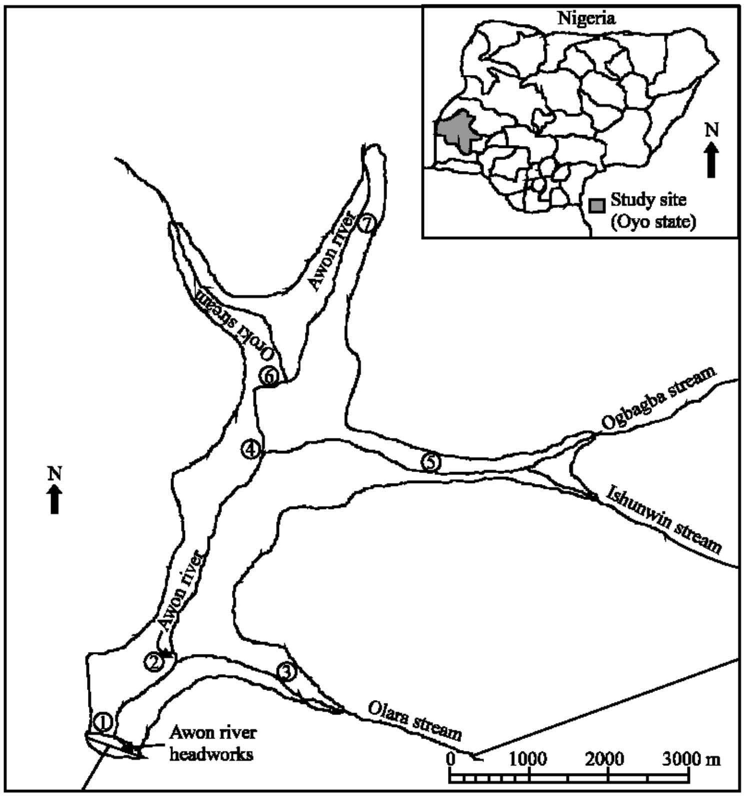

Fig. 1: Map of Awon reservoir showing sampling stations

Collection of Samples

A canoe was used during the period of investigation. Two sets of sample were collected in 250 mL plastic bottle, one for physico-chemical and the second set for biological characteristics of the reservoir. The sample for phytoplankton analysis was preserved in 4% formalin while the sample for physico-chemical characteristics was deep frozen at -4°C in the laboratory prior to analysis.

Choice of Sampling Stations

Monthly water samples were collected from seven stations created within the dam site for 2 years.

Physical and Chemical Parameters

In situ surface water temperatures were taken in the field using an ordinary mercury thermometer. Transparency was measured using a secchi disc lowered from the surface until it disappeared from view. Nitrate and phosphate ions were determined using colorimetric method. The Hach colorimetric method was used for the determination of silica ion.

Biological Analysis

Ten drops of each well-mixed sample were thoroughly investigated under a Wild binocular microscope with a calibrated eye piece. The density of the diatom species was computed by calculating average cells per transects. All counts were recorded as number of organisms (cells, colonies, filaments) mL^{-1} for the identification of organism, the keys and drawings provided by Patrick and Reimer (1966) were used.

RESULTS

The results of some physical and chemical characteristics of the Awon reservoir are shown in Table 1 and Fig. 2 and 3 for both stations. Higher temperature values were recorded in the dry season (≥ 27°C) while lower value (<27°C) were recorded in the wet season and in December (Table 1). The transparency was generally low (<40 cm) during the wet season (May-October) and there was much variation in the reservoir (Table 1, Fig. 2 and 3).

Silica values were higher during the dry season (14 mg L^{-1}) compared to wet season (Table 1). The highest peaks for nitrate values were recorded in the wet months (>2 mg L^{-1}) while the lowest values were recorded in the dry months (Fig. 2) in all stations, phosphate-phosphorus concentration (mg L^{-1}) ranged from 1.01-3.60 mg L^{-1} in the wet months and 0.03 to 2.31 mg L^{-1} in the dry months as shown in Fig. 2 and 3.

Diatom Communities

The diatom composition and abundance for some stations in *Awon* Reservoir are presented in Table 2 and 3, Fig. 4-11 show the graphical forms of the diatom abundance. Fifty four diatom species, 52 pinnate and 2 centric forms belonging to 16 genera were identified. The most abundant species of the pinnate diatoms were *Pinnularia otiensis*, *P. gibba*, *P. lata*, *Navicula menisculus*, *N. rhnchocephala*, *Kurtizing N. pseudogrimmei*, *N. acuminate*, *N. Salinicola*, *Nitzschia palea*, *Synedra, ulna*, *S. acus*, *Tabellaria fenestrata*, *Cymbella ventricosa*, *Amphora* sp.

Diatoms with 40% relative abundance or occurrence were recognized as good indicators of pollution. These diatoms are referred to as pollution tolerant species. The diatoms in this group include

Table 1: The physical and chemical characteristics of *Awon* reservoir

Diatom	Station	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Silica	1	4	2	2	4	2	8	8	8	8	12	12	2
	7	2	2	6	2	2	8	8	8	14	8	12	4
Transparency	1	30	35	58	40	36	38	48	58	60	64	60	26
	7	30	39	52	35	40	24	50	52	62	64	50	34
Temperature	1	25	25	27	24	24	27	24	27	27	27	27	24
	7	26	24	27	26	26	27	22	28	27	27	28	24
Nitrate (mg L^{-1})	1	3.20	3.60	3.00	3.64	3.64	0.80	2.00	0.80	0.60	0.44	0.84	2.02
	7	3.25	3.80	3.20	3.80	3.74	0.65	1.84	1.20	0.82	0.62	0.60	2.10
Phosphate (mg L^{-1})	1	2.0	1.5	1.5	3.0	2.0	2.0	0.96	0.96	0.56	0.35	0.46	1.51
	7	1.23	1.01	1.23	3.05	2.24	2.31	0.96	0.96	0.62	0.12	0.34	1.82

Table 1: Continued

Diatom	Station	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Silica	1	2	2	4	2	1	12	14	12	8	8	7	2
	7	2	2	2	1	1	12	18	8	14	14	12	2
Transparency	1	28	30	58	32	30	40	52	58	66	74	64	30
	7	34	30	58	32	28	38	56	66	68	64	50	36
Temperature	1	25	25	27	24	24	27	22	27	27	27	28	25
	7	24	25	26	25	25	28	22	27	27	27	27	25
Nitrate (mg L^{-1})	1	3.22	3.77	3.10	3.54	3.50	0.96	1.78	0.88	0.66	0.54	0.98	2.02
	7	3.71	3.14	3.54	3.80	3.80	0.96	1.34	0.54	0.91	0.92	0.60	2.71
Phosphate (mg L^{-1})	1	2.01	1.51	2.02	3.60	2.0	1.52	0.98	0.98	0.66	0.45	0.45	1.51
	7	1.08	1.34	1.98	3.01	2.63	1.63	0.52	0.42	0.52	0.31	0.21	

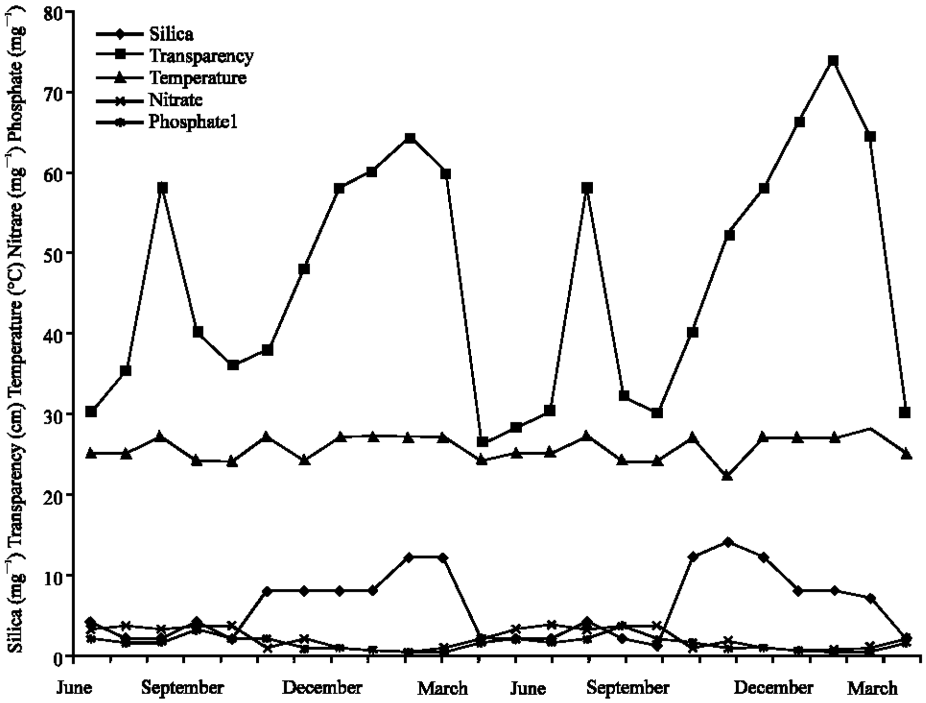

Fig. 2: The physical and chemical characteristics of *Awon* reservoir(station 1)

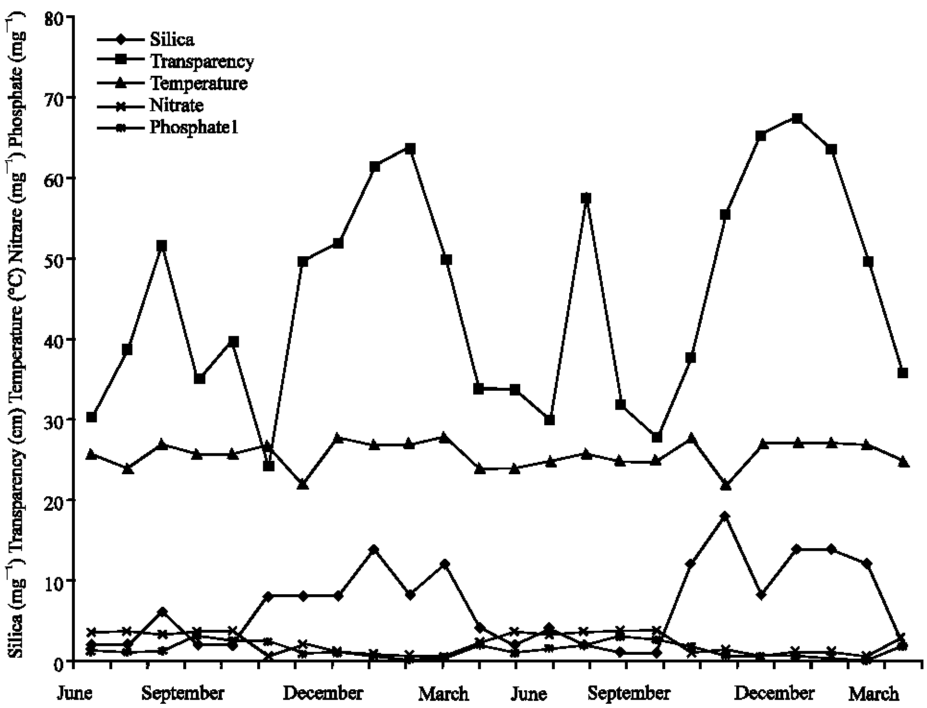

Fig. 3: The physical and chemical characteristics of Awon reservoir (station 7)

Table 2: Percentage composition of most abundant diatom taxa in station 1

Diatom	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Pinnularia gibba	57.01	50.00	5.64	25.01	26.02	-	1.08	5.64	6.06	5.64	4.34	20.01
P. borealis	-	2.90	4.34	26.02	24.01	1.08	-	4.34	4.34	4.34	5.64	3.63
P. biceps	40.00	-	4.34	5.06	6.08	-	-	4.34	5.64	3.68	4.34	3.80
P. mesolepta	1.00	-	3.64	8.06	10.02	-	-	4.36	4.36	4.36	4.36	3.95
P. lata	-	-	3.98	10.01	10.02	20.01	-	4.61	3.92	4.38	3.64	3.80
Navicula rynchocephala	-		4.64	10.02	42.01	19.01	-	3.80	-	4.38	3.46	3.80
N. mrisculas	-	-	4.46	6.01	0.80	2.01	39.08	4.02	-	3.98	3.48	3.81
Nitschia palea	-	6.50	6.40	5.01	-	10.01	-	4.08	7.08	4.64	3.98	2.91
Cymbella turgida	-	-	4.36	5.04	-	14.02	-	3.98	3.96	4.64	4.64	2.93
C. ventricosa	-	-	4.78	-	-	10.08	10.02	3.90	3.90	4.98	4.64	2.98
Synedra ulna	-	-	4.98	-	-	4.08	10.08	5.40	6.40	6.4	6.40	3.95
S. acus	1.01	-	5.68	-	0.02	1.02	10.06	5.36	4.78	4.36	4.36	3.95
Tabellaria fenestrata	-	-	5.78	-	-	1.08	9.08	4.08	4.78	4.80	4.78	4.88
Aulacoseria granulata	-	40.00	20.00	-	-	1.01	11.09	3.98	5.68	-	4.98	3.98
Amphora sp.	-	-	19.00	-	-	1.01	12.08	4.98	20.01	-	5.68	
Navicula salinicola	-	-	4.36	-	-	1.08	-	5.01	19.08	-	5.78	
N. carminata	-	-	4.36	-	-	1.20	-	5.91	-	-	-	3.95
N. psevdogrimmel	-	-	-	-	-	14.02	-	6.01	-	5.60	-	3.98

Table 2: Continued

Diatom	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Pinnularia gibba	80.0	95.0	3.98	50.01	6.08	1.08	1.90	6.01	3.90	14.34	14.01	40.02
P. borealis	10.05	2.02	3.64	19.02	10.02	-	8.20	5.92	4.36	14.34	5.64	20.06
P. biceps	1.02	1.08	4.34	-	24.01	-	2.08	5.04	5.64	5.64	8.08	3.08
P. mesolepta	1.03	0.80	5.64	0.06	26.08	-	2.06	4.96	4.34	13.64	2.08	-
P. lata	-	0.20	3.98	10.01	10.02	2.01	4.08	3.98	6.06	4.36	4.36	-
Navicula rynchocephala	-	1.00	4.64	10.02	10.08	19.01	10.02	4.08	4.34	4.38	3.64	-
N. mrisculas	-	-	13.98	6.01	4.01	20.06	19.01	5.06	5.64	3.98	3.96	-
Nitschia palea	-	-	4.64	-	0.80	10.01	-	5.64	4.36	4.64	3.48	-
Cymbella turgida	-	-	4.64	-	-	14.02	-	4.34	3.90	4.64	3.98	-
C. ventricosa	-	-	6.40	-	-	10.08	10.08	4.34	7.08	4.98	4.64	-
Synedra ulna	-	-	4.36	-	-	4.08	1.08	4.36	3.96	6.40	4.64	-
S. acus	-	-	4.78	-	-	1.02	1.02	3.64	3.90	4.36	6.40	-
Tabellaria fenestrata	-	-	4.98	-	4.08	1.08	1.03	3.80	4.78	1.02	6.80	-
Aulacoseria granulata	-	-	4.74	-	-	1.20	1.04	4.02	4.50	1.06	6.80	-
Amphora sp.	4.01	-	-	5.98	4.06	-	1.01	1.09	3.98	6.40	1.08	4.64
Navicula salinicola	4.03	-	-	6.08	-	-	1.08	1.12	4.40	4.78	10.10	4.68
N. carminata	-	-	9.08	-	-	1.20	10.04	5.36	4.40	10.12	2.08	18.01
N. psevdogrimmel	-	-	9.01	-	-	1.80	10.08	4.01	5.68	1.30	3.08	19.09

Table 3: Percentage composition of most abundant diatom taxa in station 7

Diatom	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Pinnularia gibba	40.00	45.01	20.01	1.08	40.02	1.08	2.08	10.91	2.04	2.80	2.10	40.0
P. borealis	23.01	30.02	-	2.08	24.00	1.08	10.91	2.80	2.80	2.04	10.90	20.0
P. biceps	10.02	22.01	-	2.08	16.00	2.80	10.08	2.06	10.90	10.08	10.08	-
P. mesolepta	11.04	-	18.03	10.02	5.08	15.02	19.08	2.04	2.04	10.90	2.80	-
P. lata	12.08	-	15.04	1.01	5.06	10.08	2.06	14.01	10.08	2.04	2.04	-
Navicula ryncbocephala	2.08	-	10.02	1.02	4.08	10.08	2.08	10.08	2.06	2.06	2.10	-
N. menisculus	-	-	-	1.08	3.98	5.08	2.90	2.06	19.07	2.10	2.06	23.6
Nitschia palea	-	-	20.8	1.61	-	5.06	1.48	2.08	2.010	19.00	19.00	2.06
Cymbella turgida	-	-	-	-	-	7.08	1.46	4.06	5.80	6.08	5.80	8.06
C. ventricosa	-	-	-	-	-	7.08	0.20	5.06	6.80	5.80	6.08	-
Synedra ulna	-	-	30.05	-	-	10.08	0.20	5.80	2.07	2.07	1.06	-
S. acus	-	-	-	-	-	19.08	0.20	6.82	1.02	1.06	2.07	-
Tabellaria fenestrate	-	-	-	-	-	1.08	0.80	6.83	1.06	12.02	1.02	-
Aulacoseria granulate	-	-	-	-	-	2.09	0.43	4.80	1.07	1.07	1.07	6.80
Amphora sp.	-	-	-	80.00	-	-	0.81	1.80	1.80	1.80	10.80	-
Naviculas alinicola	10.08	-	-	-	-	-	0.92	1.90	10.20	10.20	1.80	-
Navicula salinicola	-	-	-	-	-	-	28.01	2.80	11.01	11.01	10.20	-
N. psevdogrimmel	-	-	-	-	-	-	27.02	1.80	10.80	10.80	11.01	-

Table 3: Continued

Diatom	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Pinnularia gibba	45.8	42.0	10.04	2.08	1.08	15.02	12.02	2.80	9.80	1.80	2.10	3.02
P. borealis	5.00	28.00	20.012	2.08	-	2.80	3.80	2.02	6.80	9.80	10.90	9.60
P. biceps	20.50	25.00	22.01	1.08	-	1.08	1.08	10.91	3.40	7.60	10.08	10.40
P. mesolepta	-	-	-	40.02	-	1.08	2.01	2.80	9.60	8.20	2.80	-
P. lata	-	-	-	-	-	1.08	1.01	2.06	10.0	2.06	10.0	3.90
Navicula ryncbocephala	-	15.02	-	-	-	5.08	6.09	2.04	4.96	4.96	2.10	-
N. menisculus	-	-	-	30.06	-	5.06	5.06	19.01	3.96	5.95	2.06	-
Nitschia palea	-	-	30.05	-	-	7.08	8.06	10.08	10.01	6.60	19.07	-
Cymbella turgida	23.50	-	-	-	-	7.08	9.02	2.06	5.80	9.70	5.80	-
C. ventricosa	8.60	-	-	-	1.00	10.08	9.08	2.08	4.20	3.60	6.08	-
Synedra ulna	7.80	-	10.08	-	2.01	19.08	3.07	4.06	4.36	4.20	1.06	25.60
S. acus	-	-	-	-	4.01	1.08	9.08	5.08	5.08	1.80	2.07	-
Tabellaria fenestrate	-	-	-	25.30	3.01	2.09	11.02	5.90	6.80	1.80	1.02	-
Aulacoseria granulate	-	-	11.02	-	2.08	-	9.02	6.80	-	7.90	1.07	24.40
Amphora sp.	-	-	-	-	80.00	-	3.08	6.83	0.28	8.06	1.80	-
Naviculas alinicola	-	-	-	-	7.80	-	9.06	4.80	1.08	7.60	10.20	-
Navicula salinicola	-	-	-	-	-	-	9.08	1.80	-	5.80	7.20	1.04
N. psevdogrimmel	-	-	-	-	-	-	8.06	1.90	-	6.90	1.80	1.02

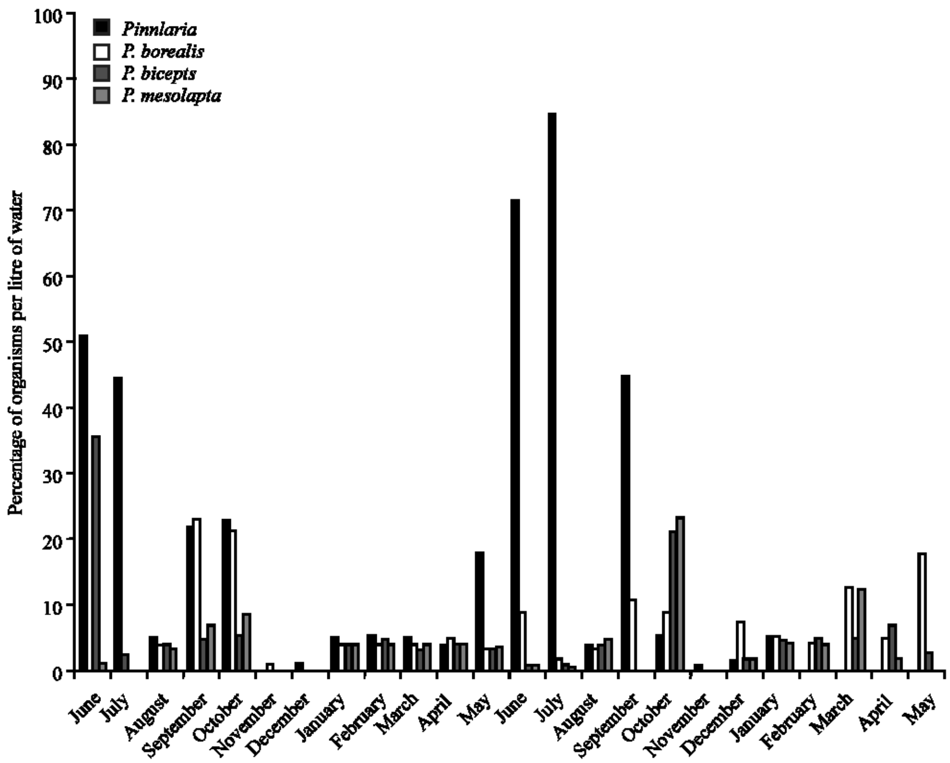

Fig. 4: Percentage composition of most abundant diatom taxa in station 1

P. lata, *P. biceps*, *Navicula rhnchocephala*, *Aulacoseira granulata*, *P. mesolepta* and *Amphora* sp. (Table 2 and 3, Fig. 4-11). In all the stations sampled, the pollution tolerant organisms were more during the wet months compared to dry months.

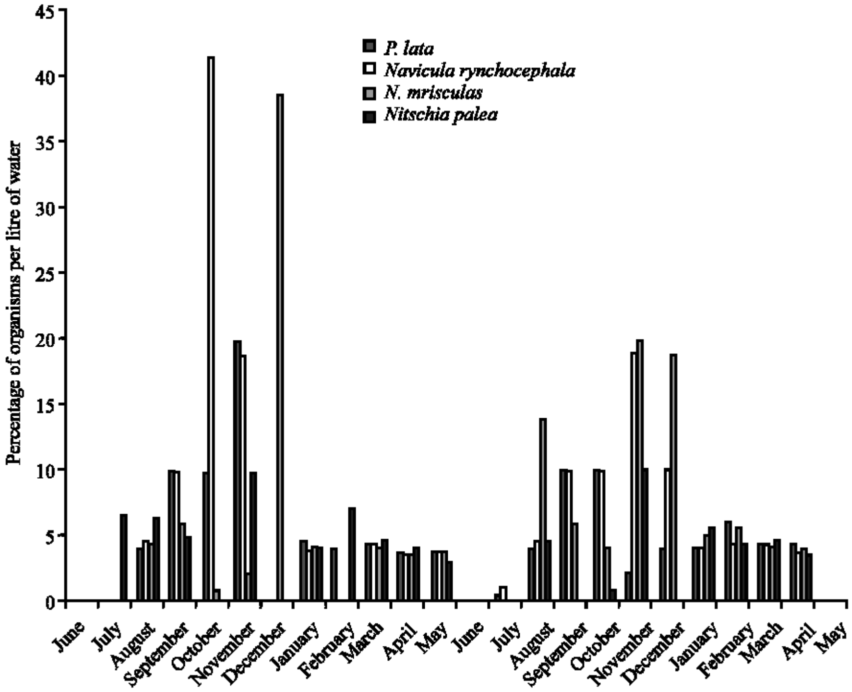

Fig. 5: Percentage composition of most abundant taxa in station 1

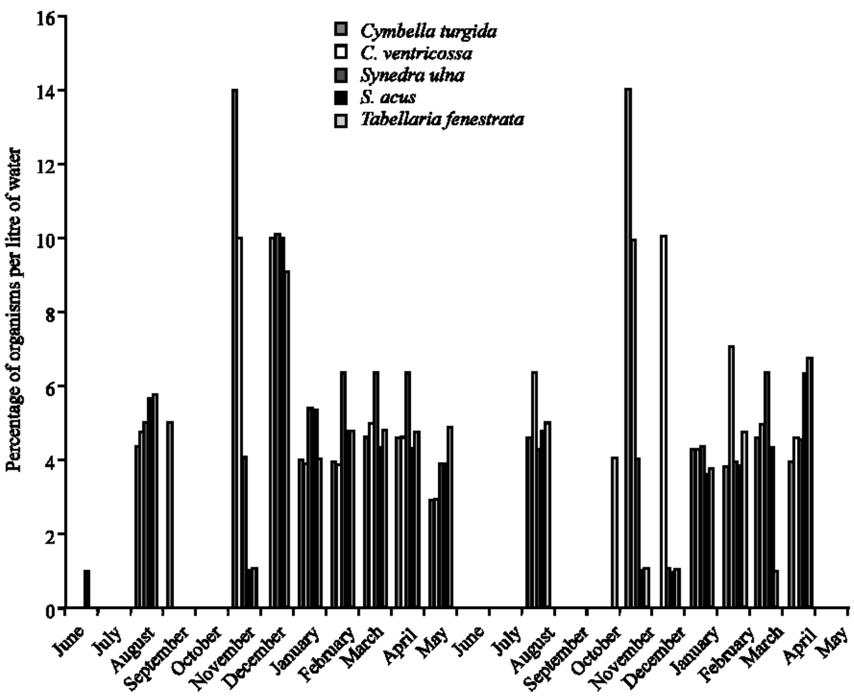

Fig. 6: Percentage composition of most abundant taxa in station 1

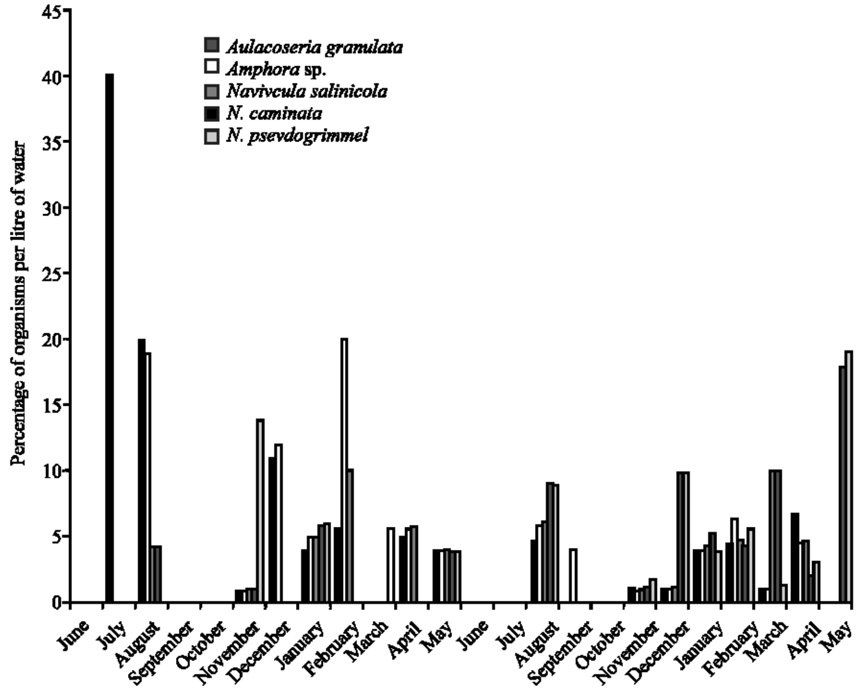

Fig. 7: Percentage composition of most abundant diatom taxa in station 1

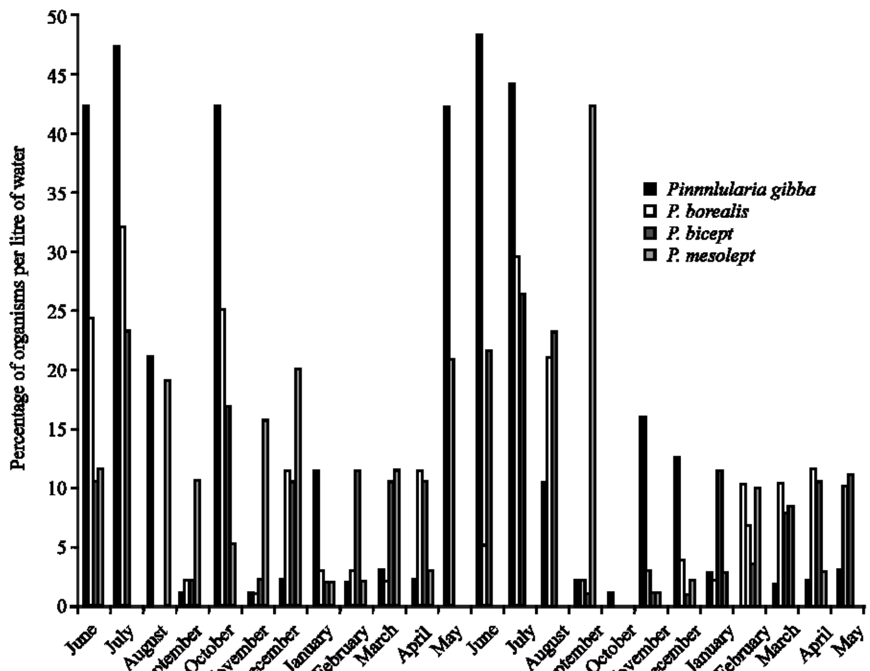

Fig. 8: Percentage composition of most abundant diatom taxa in station 7

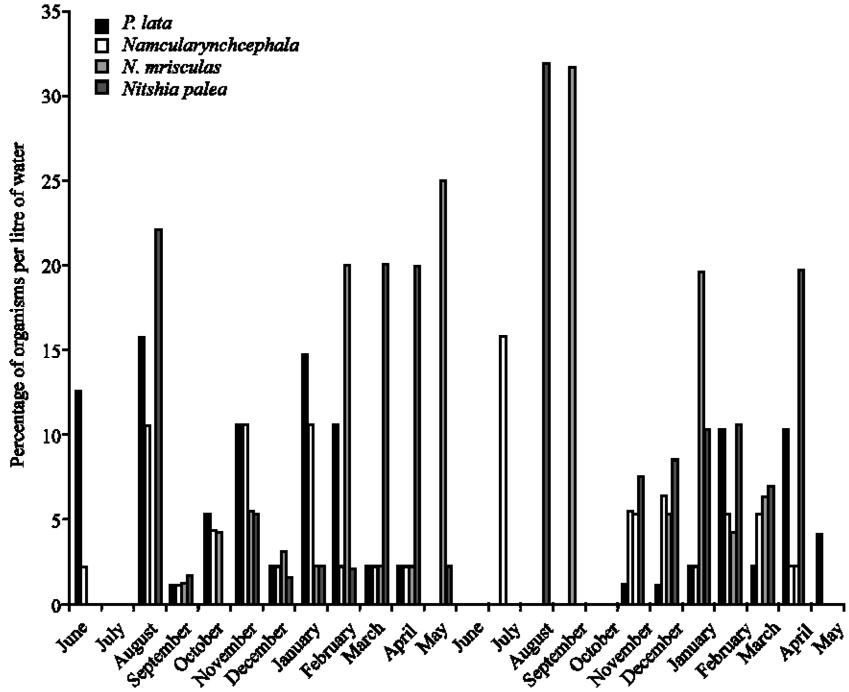

Fig. 9: Percentage composition of most abundant taxa in station 7

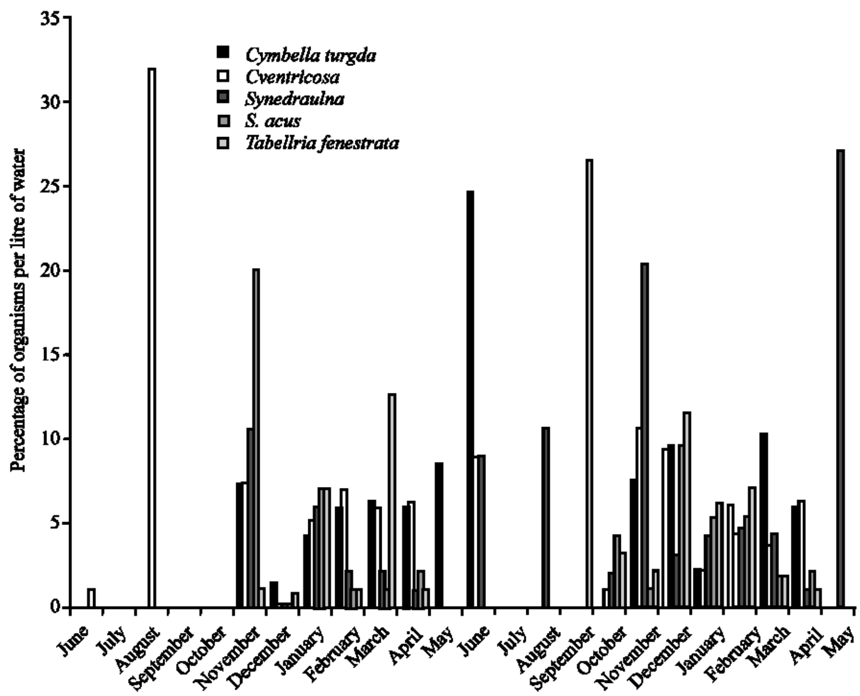

Fig. 10: Percentage composition of most abundant taxa in station 7

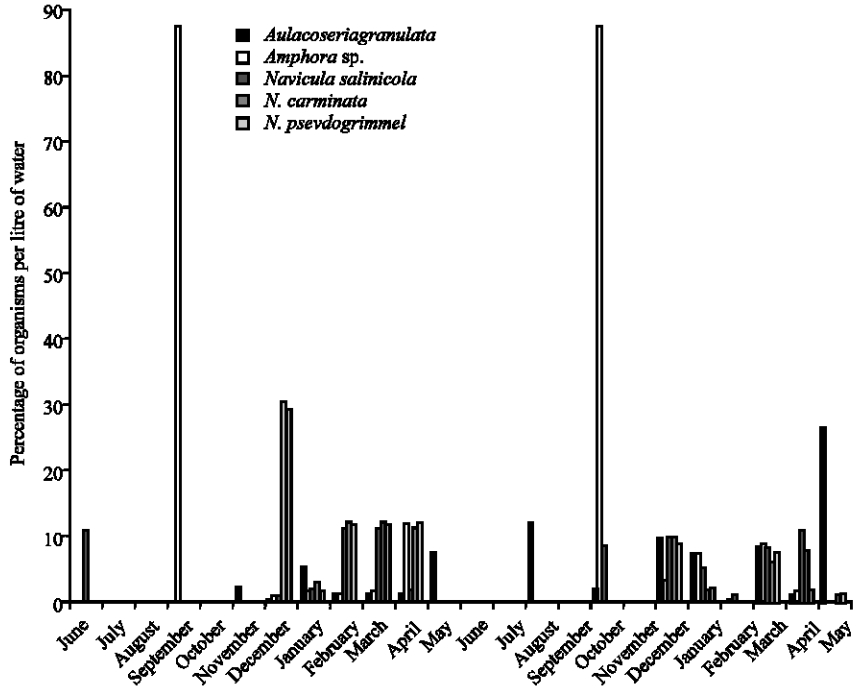

Fig. 11: Percentage composition of most abundant diatom taxa in station 7

DISCUSSION

The raining season between May and October in Nigeria was characterized by low transparency, increased nutrients concentration, increased total suspended solids, higher turbidity and increased flood water condition. This observation tallies with the work of Imevbore (1971) who concluded that the rains bring about low transparency, increased nutrient concentration and high turbidity in dams and reservoirs. The comparatively high temperature of the dry season could be due to high light intensity. The enrichment of the reservoir water in the wet season through flood water resulted in the proliferation of diatoms (Akinyemi, 2000). The higher values of nitrates and phosphates recorded during the wet months may be due to enrichment of the reservoir water from watershed during this period, which resulted in the massive growth of certain species of diatoms (Dakshini and Soni, 1982). The more rapid rate of change in diatom species composition observed during the dry months could be attributed to a more stable environment and availability of organic nutrients. Silica content of the reservoir water was found to be higher during the dry months. This substance could have been brought in during the wet months through floodwater and became concentrated as water volume reduced during the dry months (Anadu *et al*., 1990). As a result of excess nutrients during the wet season certain species of diatoms formed the dominant organisms in the reservoir. These organisms are called pollution tolerant species. The organisms are *Pinnilaria gibba*, *P. biceps*, *Navicula rhnchocephala*, *Aulacoseira granulata*, *P. mesolepta* and *Amphora* sp. The liveability and substainability of these organisms despite the stressful environmental conditions and highly turbid water qualified them as good indicators of pollution. This agrees with findings of Anadu *et al*. (1990) and Khan *et al*. (1993) who pointed out that water quality affects species composition and abundance. The present study suggests that the presence of any of these organisms in water is an indication of water pollution.

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