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RESPONSE OF FOOD ORGANISMS TO INORGANIC NITROGEN AVAILABILITY.

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ABSTRACT

Influence of inorganic N_2 forms on pond food organisms was investigated. Seven identified plankton taxa comprising four phytoplankton: Desmidiaceae (desmids), Bacillariophyceae (diatoms), Cyanophyceae (blue-green algae) and Chlorophyceae (green algae) and three zooplankton: Protozoa, Cladocera and Rotifera fluctuated in response to nutrient inputs. All recorded significant F-value across treatments. With exception of blue-green algae, other phytoplankton groups had comparable relative abundances in treatment with higher concentration of readily utilized. Nitrate-Nitrogen (NO_3-N) compared with control that recorded higher concentration of Ammonia-Nitrogen (NH_3-N) and increased relative abundance of blue-green algae. Zooplankton exhibited same dominance pattern of Protozoa, Rotifera and Cladocera respectively, with treatment recording higher abundance in response to edible phytoplankton. N_2 from zooplankton excretion influenced phytoplankton responses in the control. Ammonia-Nitrogen (NH_3-N), Nitrate-Nitrogen (NO_3-N) and Nitrite-Nitrogen (NO_2-N) were observed to fluctuate along nutrient enrichment profile depending mostly on the concentrations of intermediate Nitrite-Nitrogen (NO_2-N). All nutrient parameters except NH_3-N recorded significant t and F statistic between and across treatments. Water quality parameter of pH and dissolved oxygen were favourable for most period of the experiment.

KEYWORDS: Nutrient, Plankton, Ammonia-Nitrogen, Nitrate-Nitrogen, Nitrite-Nitrogen.

INTRODUCTION

Food organisms for pond culture referred to as plankton are limited by two main nutrients: phosphorus and nitrogen related to stoichiometric ratios (Hecky and Kilham, 1988). The importance of different N_2 forms is that most edible phytoplankton are not N_2 fixers and do not assimilate from diverse sources, but absorb inorganic forms (nitrates, nitrites and ammonia) present in water column (Falkowski and Raven, 1997). Therefore easily outnumbered and out-competed by fixers which are of low nutritional importance in pond culture (Pearl and Tucker, 1995) at periods of N_2 restriction. The results of this study aims to add to body of information on relationship between food organisms and different inorganic nitrogen forms.

MATERIAL AND METHODS

The experiments were conducted at the Zoology Department, University of Ibadan, Nigeria, in $0.90m^2$ partially shaded open concrete tanks, containing 2cm thick layer of sand. Water from Oba dam was used and maintained at 50cm mark. There were 2 sets of experiments each consisted of duplicated treatment and control. The experimental setup was maintained without fertilization for 1week to allow stabilization of plankton population. Ammonium sulphate (0.01kg) was applied at the rate of 112kg/ha as recommended by Gratzek and Brown (1980). Two applications were made at 15 days interval. Thirty three days inorganic nitrogen profile was evaluated at 3-day interval through the concentrations of the following: Ammonia-Nitrogen (NH_3-N), Nitrate-Nitrogen (NO_3-N) and Nitrite-Nitrogen (NO_2-N) measured respectively by phenate, phenol disulphonic acid and sulphanilamide methods recommended by Boyd (1979) and APHA (1985). Dissolved Oxygen Concentrations (DO_2) was determined by Winkler's (Azide) titrimetric method (APHA, 1985) and pH by using PS17 Corning probe. Average water temperature for the duration of the experiment was 28.7^{0}C. Plankton samples were collected simultaneously using 64µm bolting silk net, and preserved with 4% formalin. The counting was done on a 15ml counting plate and composition determined by direct proportion in 1ml. Identification was with guides of Needham and Needham (1978), Pennak (1978) and Jeje and Fernando (1986). Treatment means were compared using t-test and One-way ANOVA (Sokal and Rohlf, 1987).

RESULTS

The summary of experimental results is

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Table 1 Summary and comparison of water quality parameters

	Trials	Mean	t	F
Ammonia-Nitrogen (mg/l)	1	6.21± 3.87		
	Control	4.66±1.61	1.65	
	2	6.42±4.13		1.20
	Control	4.67±1.37	1.72	
Nitrate-Nitrogen (mg/l)	1	5.87±5.48		
	Control	2.01±1.39	2.47*	
	2	4.99±5.47		3.59*
	Control	1.43±1.32	2.40*	
Nitrite -Nitrogen (mg/l)	1	5.69±2.5		
	Control	3.16±1.59	3.53*	
	2	1.79±1.40		20.81*
	Control	0.32±0.12	3.39*	
Dissolved oxygen (mg/l)	1	1.66±1.21		
	Control	1.59±1.10	0.82	
	2	1.50±1.64		0.06
	Control	1.45±1.30	-1.21	
pH	1	7.28±0.45		
	Control	7.19±0.44	0.44	
	2	7.21±0.44		0.11
	Control	7.28±0.47	0.36	

* significant at 0.05

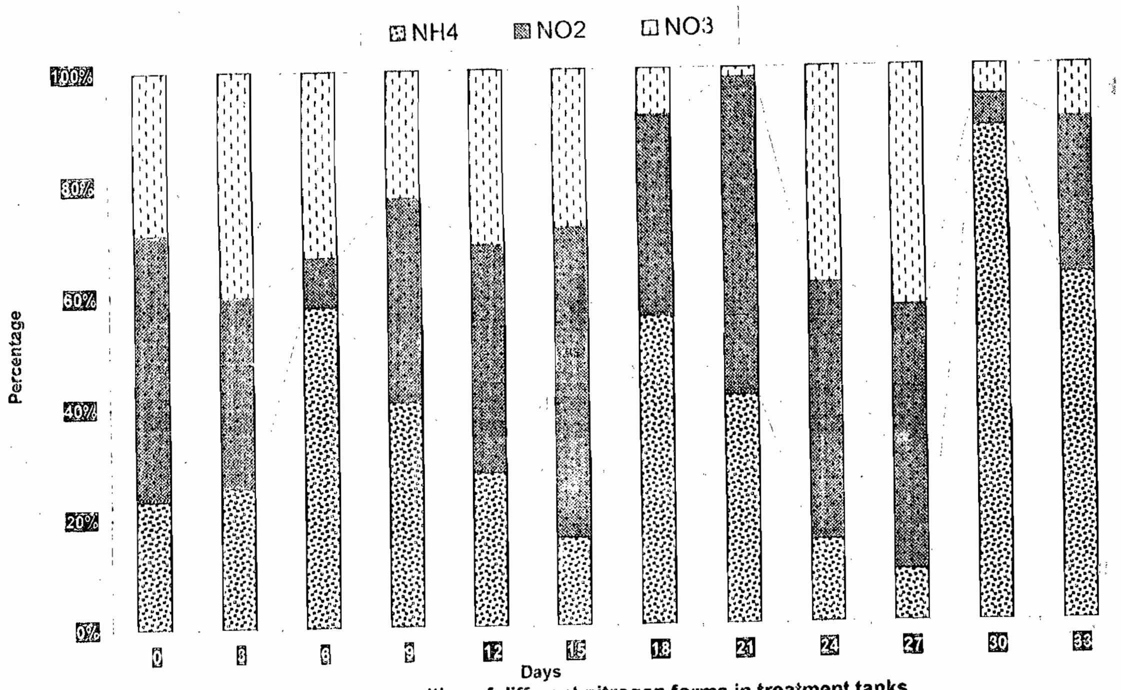

Fig.1 Percentage composition of different nitrogen forms in treatment tanks

presented in Table 1. Three N_2 forms recorded higher mean treatment values in all cases compared with control. NO_3-N and NO_2-N recorded significant t and F values indicating significant mean differences between duplicates and across treatments. Changes in percentage proportion of N_2 forms is shown in Figs. 1& 2 for treatments and controls respectively. NH_3-N and NO_2-N exhibited inverse changes in concentrations, clearly depicted 6 days after first application with noticeable increase in NH_3-N concentration followed by same magnitude of decrease till second fertilizer application. Similar post application changes were however observed after 3 days (Fig. 1) followed by near absence of NO_3-N and NO_2-N, with ~90% NH_3-N, which reduced to 65% at termination. The concentration of NO_3-N exhibited different profile with a 29% proportion at the commencement, which increased to about 46% and decreased

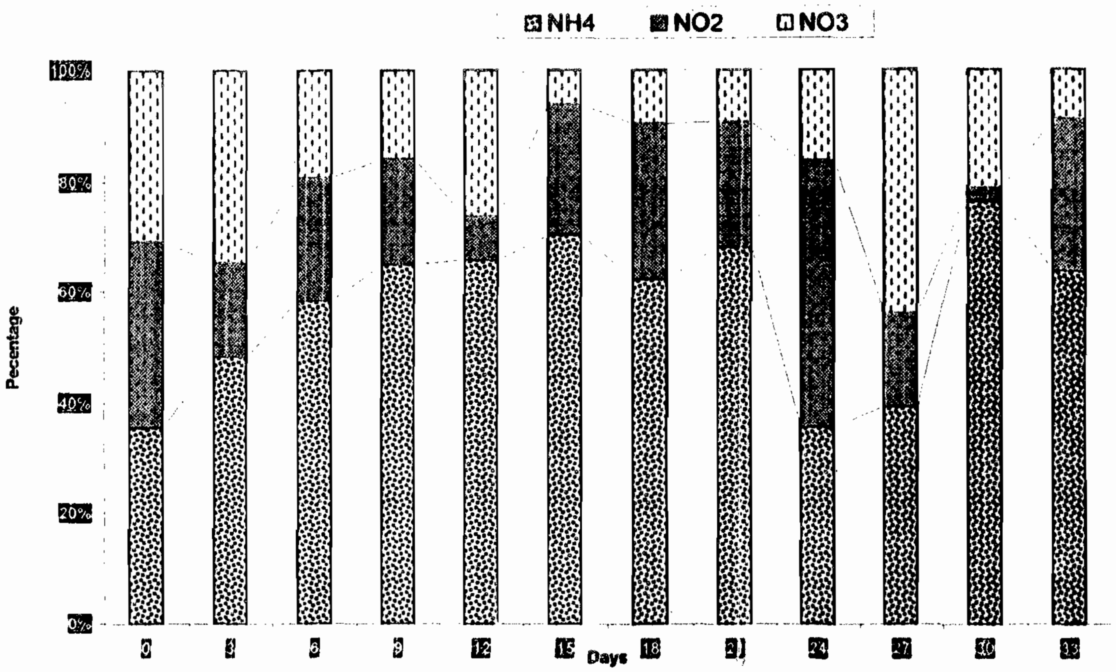

Fig.2 Percentage composition of nitrogen forms in control tanks

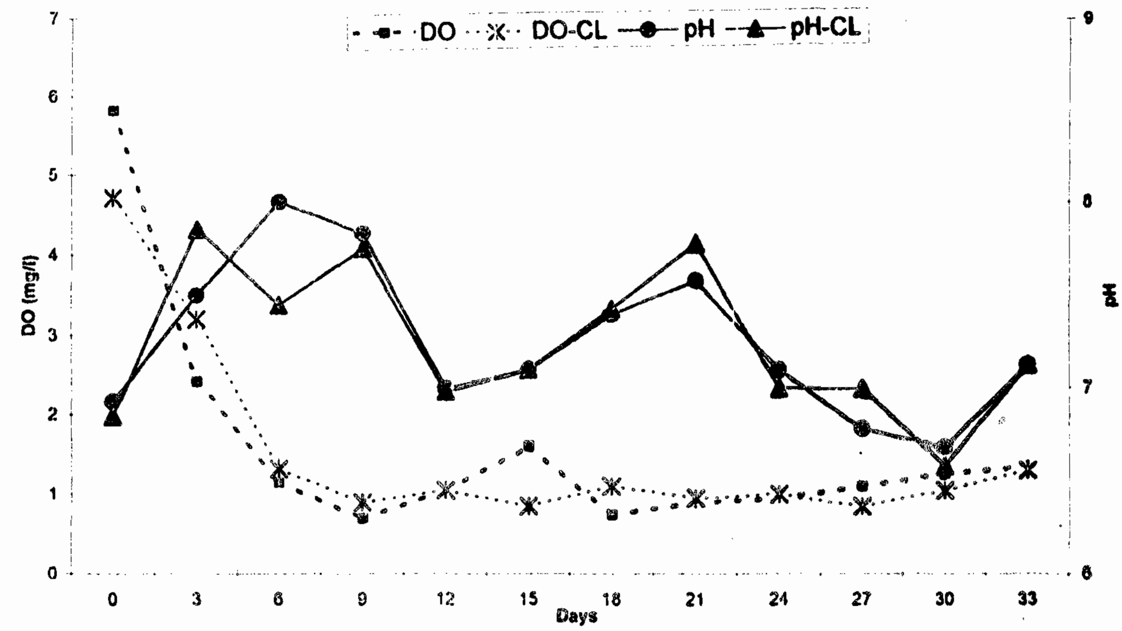

Fig.3 pH and dissolved oxygen concentration changes in treatment and control tanks

consistently to ~25% at day 15. Six days after second application it almost zeroed. A sharp 42% increase by day 27 decreased to less than 10% at termination. Similar inverse relationship was observed between NH_3-N and NO_2-N for the control (Fig. 2) but fluctuated differently. NH_3-N recorded the highest (35% - 73%) proportion except day 24 (34%) and day 27 (38%). NO_2-N followed a similar but inverse trend. NO_3-N fluctuated markedly with the highest of about 45% recorded by day 27. Water quality parameters of pH and DO_2 changes for the period of experiment is presented as Fig. 3. The pH attained post application maxima of 8.1 and 7.6 in 6 days followed steep decline to 6.8 and 6.5 respectively. The control fluctuated along similar increase-decrease regimes with minimum and maximum of 6.5 and 7.8. DO_2 fluctuated along similar pattern for the treatments and control with sharp post fertilization decline which remained low except at day 15 for the treatment (1.30mg/l). Both recorded marginal differences between treatment and control means without significant t and F values (Table 1).

The relative plankton abundance for the treatment and control tanks is presented in Figs. 4 and 5. Total of seven taxa comprising four phytoplankton of Desmidiaceae (desmids), Bacillariophyceae (diatoms), Cyanophyceae (blue-green algae) and Chlorophyceae (green algae) and three zooplankton of Protozoa, Cladocera and Rotifera were identified. Phytoplankton was dominated by green algae with maximum relative abundance (~ 70%) after second fertilizer application, however desmids attained dominant status of 54. 5% abundance in the last six days. The blue-green algae were the least represented with a maximum percentage abundance of 6%. Diatoms recorded moderate abundance with range of 10% - 35%. Zooplankton fluctuated greatly with clear dominance by protozoa with maximum of 24% relative abundance. It was followed by rotifers (11%) and cladocerans (6%). The control was alternately dominated by green algae with a range of 3% - 65% and desmids the concluding nine days with a range of 13% - 46% (Fig. 5). While the blue-green algae was similarly the least represented (~12%). The diatoms recorded reduced relative abundance, a maximum of ~10%. The protozoans also dominated zooplankton attaining maximum abundance of 21% at termination. Significant differences were observed among the plankton group (Fig. 6).

DISCUSSION

Fertilization primarily increases productivity by release of soluble nutrients of which nitrogen in different forms is a known part of these processes

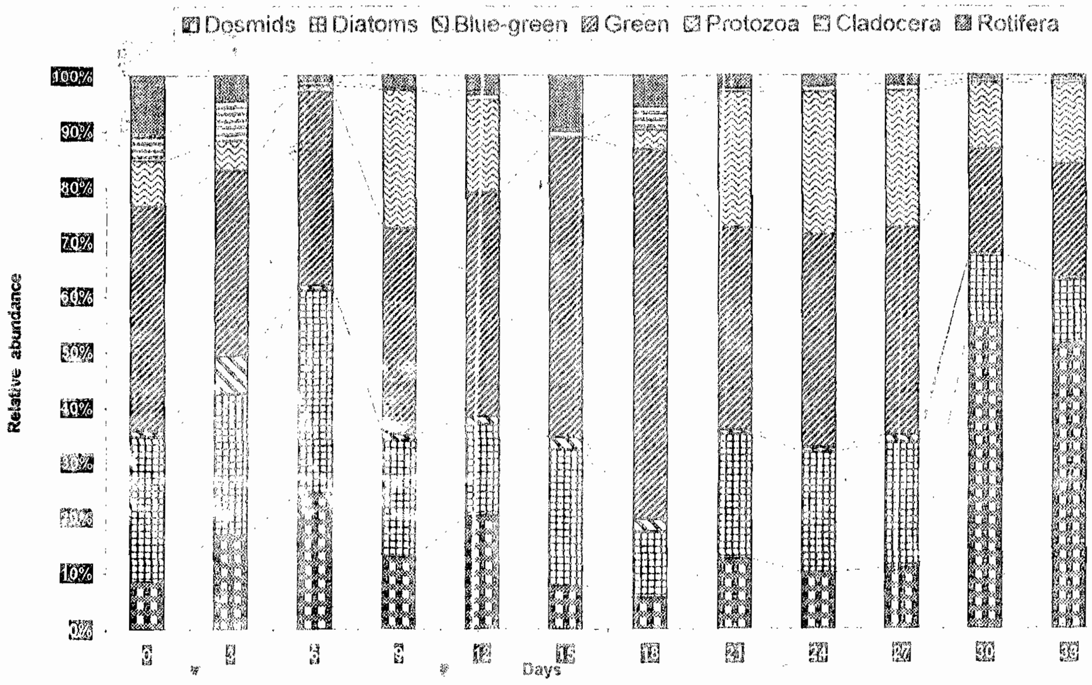

Fig.4 Relative plankton abundance for treatment tanks

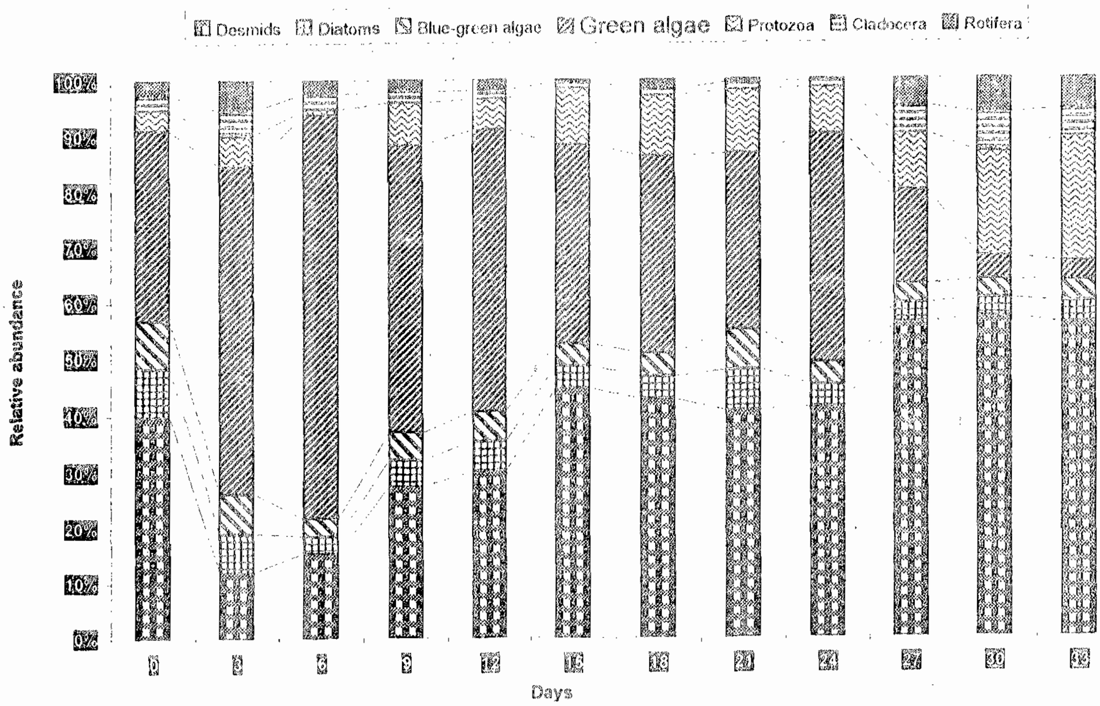

Fig.5 Relative plankton abundance in control tanks

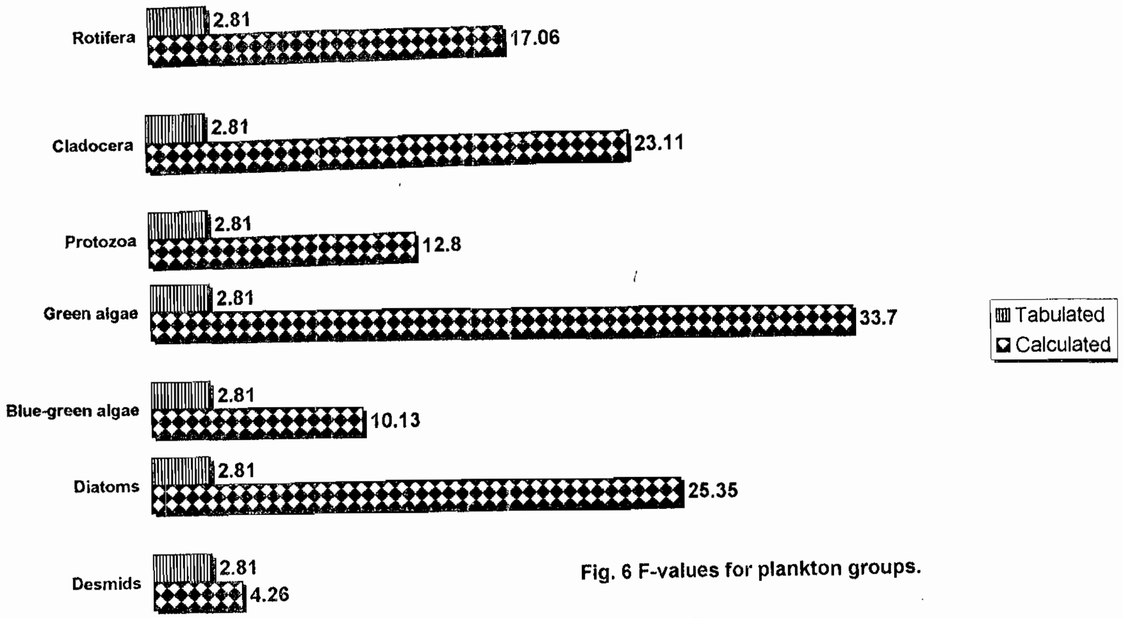

Fig. 6 F-values for plankton groups.

leading to higher productivity. From our results nitrogen forms in treatment tanks recorded increases and declines in concentrations after the fertilization, in agreement with observations of Boyd (1979). The concentration of NO_2-N affects the concentrations of NH_3-N and NO_3-N in the biologically mediated processes, catalyzed via two nitrite intermediate steps in presence of oxygen (Boyd, 1979; Falkowski and Raven, 1997). This transformation was highly favoured by the suitable pH and temperature. Denitrification by heterotrophic bacteria and phytoplankton especially the diatoms with corresponding periods of high density and low DO generated unusual concentrations of NO_2-N and NH_3-N by high rate of biological decomposition in treatment tanks respectively. The observed accumulation of NH_3-N in the control tanks could have similarly, resulted form higher rate of biological decomposition compared with biological recruitment resulting from reduced nutrient availability. This probably accounted for the low DO in the control tanks. Thus differences in statistical significance of nutrient and water quality parameters.

The variations in plankton density indicated clearly the influence of external nutrient inputs (Jeje, 1986; Brummet, 2000; Jeje and Sowunmi, 2000) and Rabalais (2002) gave excellent examples of studies that reported significant positive relationships between nutrient loading and algal biomass. This accounted for the significant differences across treatments and controls. The relative abundance of each taxa reflected the ability to utilize N_2, in addition to other necessary nutrients; while the zooplankton reflected the presence and utilization of food organisms. The dominance by non-nitrogen fixing algae (i.e. desmids, diatoms and green algae) indicated that the tanks were not nitrogen restricted, in contrast to the control which had no additional N_2 inputs hence reduced N:P thus favoured dominance by blue-green algae (Figs. 4&5), similar to observations of Smith (1983) and Paerl and Tucker (1995). However, the relative phytoplankton abundance in the control especially for desmids and green algae appeared to be near maximum suggestive of nutrient patchiness from zooplankton excretion as has been reported by Sterner (1986) and Kilham and Hecky (1988). Rabalais (2002) in her review noted this feature of uncommon singular nutrient limitation in freshwater system compared with marine systems. In both the treatment and control tanks all the zooplankton taxa fluctuated along similar pattern i.e. Protozoa, Cladocera and Rotifera with treatment tanks recording higher abundances. According to Infante and Edmonton (1985) and Rothhaupt (1995) structure and dynamics of zooplankton are highly dependent on the availability and quality of edible phytoplankton species. The available phytoplankton taxa with exclusion of blue green algae were among those generally considered to be of good quality to zooplankton (Infante and Edmonton, 1985; Paerl and Tucker, 1995; Rothhaupt, 1995). However, in this study an additional factor will have to be considered: algal nutrient limitation. Rothhaupt (1995), established a reduction in zooplankton growth rate in nutrient limited environment and concluded that nutrient limitation greatly altered food quality hence mineral nutrient in the zooplankton.

REFERENCES

APHA, 1985. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington, DC, 1107pp

Balarin, J. D. and Hatton, J. P., 1979. Tilapia: A guide to their biology and culture in Africa. University of Stirling, Scotland. pp174.

Boyd, C. E., 1979. Water quality in warm water pond. Auburn University Agricultural Experimental Stations. pp353.

Brummett, R. E., 2000. Food organism availability and resource partitioning in organically and inorganically fertilized *Tilapia rendalli* ponds. *Aquaculture* 183: 51-71.

Chikafunba, F. J. .K., 1996. The use of napier grasss (*Pennisetum purpureum*) and maize *(Zea mays)* bran as low cost tilapia aquaculture inputs. *Aquaculture,* 146: 101-107.

Chikafunba, F.J.K., Costa-Pierce, B.A., Jamu, D.M., Kadongola, W. K. and Balarin, J. D., 1993. The investigation on the use of on-farm resources as pond inputs to culture *Tilapia rendalli* and *Oreochromis shiranus* on smallholder farm in rural Malawi. *Aquaculture,* 117: 20-27.

Edwards, P., Pacharaprakiti, C. and Yomjinda, M., 1994a. An assessment of the role of buffalo manure for pond culture of tilapia I. On station experiment. *Aquaculture,* 126: 83-95.

Edwards, P., Keawpaitoon, O., Little, D.C. and Sipandh,N. 1994b. An assessment of the role of buffalo manure for pond culture of tilapia II. Field trial. *Aquaculture,* 126: 97-106.

Falkowski, P.G. and Raven, J. A. 1997. Aquatic photosynthesis. Pub. Blackwell Sci. Inc. Ma. pp300-335.

Infante, A and Edmonton, W. T., 1985. Edible phytoplankton and herbivorous zooplankton in Lake Washington. *Arch. Hydrobiol. Beih. Ergebn. Limnol.* 21: 161-171.

Ita, E. O. 1980. A review of recent advances in warm water aquaculture research and a proposed experimental design for maximizing fish production in Nigeria for fish ponds. *Kainji Lake Res. Inst. Tech. Rep. Series* 5.

Jeje, C. Y. and Fernando, C. H., 1986. A practical guide to the identification of Nigerian zooplankton *(Cladocera, Copepoda and Rotifera)*. Kainji Lake Research Institute. pp142.

Jeje, C.Y., 1986. The influence of nutrients enrichment on plankton and fish production ponds. Ph.D thesis, Depaprtment of Zoology, University of Ibadan, Ibadan.

Paerl., H. W. and Tucker, C. S., 1995. Ecology of blue-green in Aquaculture. *J. World Aqua. Soc.* 26(2): 109-131.

Pennak, R.W., 1978 . Pub: John Wiley and Sons New York. pp 80-551.

Rabalais, N. N., 2002. Nitrogen in aquatic ecosystems. *Ambio* 31: 102-112.

Rothhaupt, K. O., 1995. Algal nutrient limitation affect rotifer growth rate but not ingestion rate. *Limnol. Oceanogr.* 40(7): 1201-1208.

Shevgoor, L., Knud-Hansen, C.F. and Edwards, P., 1994. An assessment of the role of buffalo manure for pond culture of tilapia III. Limiting factors. *Aquaculture,* 126: 107-118.

Smith, V. A., 1983. Low nitrogen to phosphorus ratios favour dominance by blue-green algae in Lake phytoplankton. *Science* 221: 669-670.

Sokal, R. R. and Rohlf, F. J., 1987. *Introduction to Biostatistics.* W. H. Freeman and Company, N.Y. pp.949120.

Sterner, R. W., 1986. Herbivores' direct and indirect effects on algal populations. *Science* 231: 605-607.

Tobor, J. G., 1993. Fin and shellfish of conservation interest in Nigeria. *Proc. Nat. Confer. on Conservation of Aquatic Resources.* Fed. Dept. Fisheres and NIOMR. pp129-145.

Tobor, J. G., 1994. A fisheries policy for Nigeria. *NIOMR Tech paper* 97, 5-6.

Ugwumba, A.A.A., 1993. Management in aquaculture. Monthly technology review Ogun State Agricultural Development Project Abẹokuta, Nigeria. pp11.