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# Effect of liming and fertilization on phytoplankton distribution and primary productivity of tropical earthen ponds.

**E. Ekpenyong[1]**

**ABSTRACT**

To investigate the effect of liming and fertilization on plankton distribution and productivity, 12 earthen fish ponds, each measuring 25m$^2$ were subjected to four different treatments, in triplicate. The treatments were no liming, no fertilization (NL/NF), liming and fertilization with cow dung (L/cow), liming and fertilization with chicken droppings (L/chick) and liming and fertilization with NPK, 15: 15: 15 (L/NPK). Phytoplankton distribution and primary productivity showed marked variation among the treatments. Phytoplankton diversity ranged from 2.38 in L/cow to 3.39 in NL/NF. The least productive pond was the control pond (0.25 mg $0_2$ m$^{-2}$ hr$^{-1}$) while the most productive was L/chick (0.83 mg $0_2$ m$^{-2}$ hr$^{-1}$). Although nutrient loading resulted in decreased diversity, it actually enhanced significant increases in abundance of the highly nutritious diatoms and primary productivity. From the above findings, chicken droppings is recommended for fish pond fertilization considering cost effectiveness.

**Keywords:** Liming, fertilization, primary productivity, tropical earthen ponds.

## INTRODUCTION

Phytoplankton forms the major portion of primary producers in the aquatic environment and like the land plants, they constitute the basic food for consumers including fish, in the aquatic ecosystem. Fish culturists have frequently reported that application of liming agents to fish ponds on soils of low calcium content resulted in greater fish production (Ness, 1948; Hickling, 1962). Zeller and Montgomery (1958) and Thomaston and Zeller (1961) reported that addition of fertilizers did not produce adequate phytoplankton in many ponds in Georgia with soft waters and acid bottom muds because carbon dioxide was in short supply and the added phosphate (fertilizer) was tightly absorbed by bottom muds. Application of liming materials to these ponds elevated total and bicarbonate alkalinity and increased the pH of the waters. Neutralization of bottom mud acidity with lime decreased phosphate absorption and this increased phosphorus concentrations in the water. As a result of these changes in mud and water chemistry following liming, phytoplankton blooms developed upon application of fertilizers.

Literature abounds on plankton distribution in Nigerian freshwater ecosystems. Prominent among the available records are those of Imevbore (1967, 1968), Adeniyi (1978), Egborge (1971, 1979), Biswas (1984), Nwadiaro and Ezefili (1986), Biswas and Neweze (1990), Kadiri (1992), Akpan and Okafor (1996) and Ekpenyong (1996).

Phytoplanktons are the basic food items in the fish pond ecosystem as is usually the case in extensive aquaculture. There is therefore, a strong need to explore the possibilities of increasing the production of natural foods in ponds, using readily available manures and fertilizers.

## MATERIALS AND METHODS

Twelve earthen fish ponds each measuring 35m$^2$ and located at the Unical Fish Farm were used for the present study. Each experiment had three replicates. With exception of the first pond which was neither limed nor fertilized (NL/NF), the other ponds were limed with 139 Kg ha$^{-1}$ of calcium carbonate by spreading it on the pond bottoms according to Boyd (1982). Thereafter, the lime was covered with sharp sand (about 1cm thick) before flooding with water. The second was fertilized with cow dung (L/Cow), at the rate of 11 Kg ha$^{-1}$ the third, fertilized with chicken droppings (L/Chick) at the rate of 5.5 Kg ha$^{-1}$ while the fourth was limed and fertilized with NPK 15.15.15 (L/NPK) at the rate of 2.75 Kg ha$^{-1}$.

Plankton samples were collected fortnightly between February 1991 and January 1992, using a plankton net (mesh size, 54µm. Examination was done using live specimens immediately on getting to the laboratory. Examination of live specimens is advantageous in that it is easier to identify the specimens when they are still moving and all their parts are intact. However, where examination of fresh samples was not possible, they were preserved in 4% formalin for

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[1]Department of Zoology, University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria.

future examination.

Identification of the phytoplankton species was accomplished with the help of standard texts and reference materials (Ward and Whipple, 1959, Imevbore, 1968; Prescot, 1970; Egborge, 1973; Hutchinson, 1975; Fritsch, 1975; Willoughby, 1976; Bold and Wynne, 1978; Needham and Needham, 1978; Standard Methods, 1980 and Ekpenyong, 1982, 1996)

Phytoplankton abundance was obtained by counting the number of each species in a counting chamber (1ml capacity) Sedgwick-Rafter (S-R) model and expressing this per litre of the original sample using the formula:

$$A = \frac{ab}{cd} \, x \, 100$$

where: A is the abundance of the species per litre; a is the abundance of the species in the counting chamber; b is the concentrate volume of the water used; c is the volume of the counting chamber and d is the original volume of the water used (Adeniyi, 1978).

Also, the qualitative composition of the phytoplankton and their frequency of occurrence in each of the treatments was determined from the relationship:

$$OC = \frac{a}{b} \, x \, 100$$

where: OC is the frequency of occurrence of each species of plankton; a is the number of plankton species under consideration and b is the total number of all the species in the division of plankton under consideration (Ekpenyong, 1996). Also, phytoplankton species diversity was calculated using the Gleason Index ($D^{/}$) according to Margalef (1968) as follows:

$$D^{/} = \frac{\mathrm{s - 1}}{\mathrm{InN}}$$

where: S is the total number of genera and N is the total number of phytoplankton (cells). Primary productivity of the ponds was determined by "light and dark bottle" technique following changes in the dissolved oxygen in a water sample using the Winkler titrimetric method.

## RESULTS

The total number of the different species in each Division as well as their percentage contribution in the various treatments is given in Table 1.

Altogether, five phytoplankton Divisions - Chlorophyta, Euglenophyta, Cyanophyta, Chrysophyta and Pyrrophyta, made up of 40 genera and 66 species, were observed during the study. From Table 1, all the ponds were dominated by Chlorophyta which accounted for between 48.4% in the limed, NPK fertilized pond (L/NPK) and 62.5% in the limed, chicken droppings fertilized pond (L/Chick). Next in abundance were Euglenophyta except in the unlimed, unfertilized pond (NL/NF) and the limed NPK fertilized ponds (L/NPK) where Chrysophyta were the next. For all the treatments, Pyrrophyta contributed the least with number of species varying between one and three.

The composition and percentage occurrence of phytoplankton in the various treatments are shown in Table 2. Most of the species were within the 1 – 19% group in all the treatments. Only one species M*elosira granulata* (Division, Chrysophyta) fell within the 80 – 100% group in the limed, cow dung fertilized pond (L/cow) while another species, P*eridinium pulsilum,* was also in the same group in the limed, chicken droppings (L/Chick).

Diversity Index (D.I.) was highest (3.39) in the unlimed, unfertilized pond (NL/NF) while lower values (between 2.38 and 2.50) were recorded for the limed, fertilized ponds (Fig. 1). From Fig. 2, which shows both the net and gross productivity values, unlimed, unfertilized pond (NL/NF) recorded the least values. When considering the various fertilizers, chicken droppings recorded the highest values of 0.54 and 0.83 mg $O_2$ $m^{-2}$ $hr^{-1}$ for the net and gross productivity respectively, while the least productive was NPK-fertilized pond.

## DISCUSSION

The observed dominance of the phytoplankton by Chlorophyta is a common occurrence in earthen ponds. For example Ekpenyong (1982, 1996) reported that the phytoplankton was dominated by Chlorophyta. Boyd (1982) also had a similar result while working on some fish ponds at Auburn University, U.S.A. From the above findings, it may be pertinent to conclude that the phytoplankton composition of the fish pond ecosystem whether fertilized or not, is usually dominated by Chlorophyta. Euglenophyta, were the next dominant group especially in the ponds treated with cow dung and chicken droppings probably due to the fact they thrive best in environments that have been contaminated with feacal materials from farm animals such as the ones used in the present study.

According to Swingle (1947), the theory that like causes produce like effects certainly does not appear to apply in the case of production of planktonic algae by fertilization. While using a series of ponds with a common water supply and practically identical in length, width and depth, he observed that when given the same fertilizer treatment, no two had the same appearance either to the naked eye or microscope. A similar observation was made during the present study. No particular species was either station-specific or observed to dominate others for a long time. Pond production therefore, appears to result in the production of an unpredictable mixture of algae as already pointed out by Swingle (1947).

The observed high Diversity Index of 3.39 obtained for the unlimed, unfertilized pond (NL/NF) compared with that of limed, fertilized ponds, corroborate those of McArthur and McArthur (1961), who also obtained higher number of species in the unlimed, unfertileзed pond than in those undergoing liming and fertilization.

**Table 1. Divisions of phytoplankton and their percentage occurrence in the different treatments.**

| Division of | NL/NF | | L/Cow | | L/Chick | | L/NPK | |
|---|---|---|---|---|---|---|---|---|
| **Phytoplankton** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** |
| Chlorophyta | 21 | 50.0 | 17 | 56.7 | 20 | 62.5 | 15 | 48.4 |
| Euglenophyta | 6 | 14.3 | 8 | 26.7 | 5 | 15.6 | 5 | 16.1 |
| Cyanophyta | 5 | 11.9 | 3 | 10.1 | 4 | 12.5 | 3 | 9.7 |
| Chrysophyta | 7 | 16.7 | 1 | 3.3 | 2 | 6.3 | 5 | 16.1 |
| Pyrrophyta | 3 | 7.1 | 1 | 3.3 | 1 | 3.1 | 3 | 9.7 |
| **Total** | **42** | **100.0** | **30** | **100.0** | **32** | **100.0** | **31** | **100.0** |

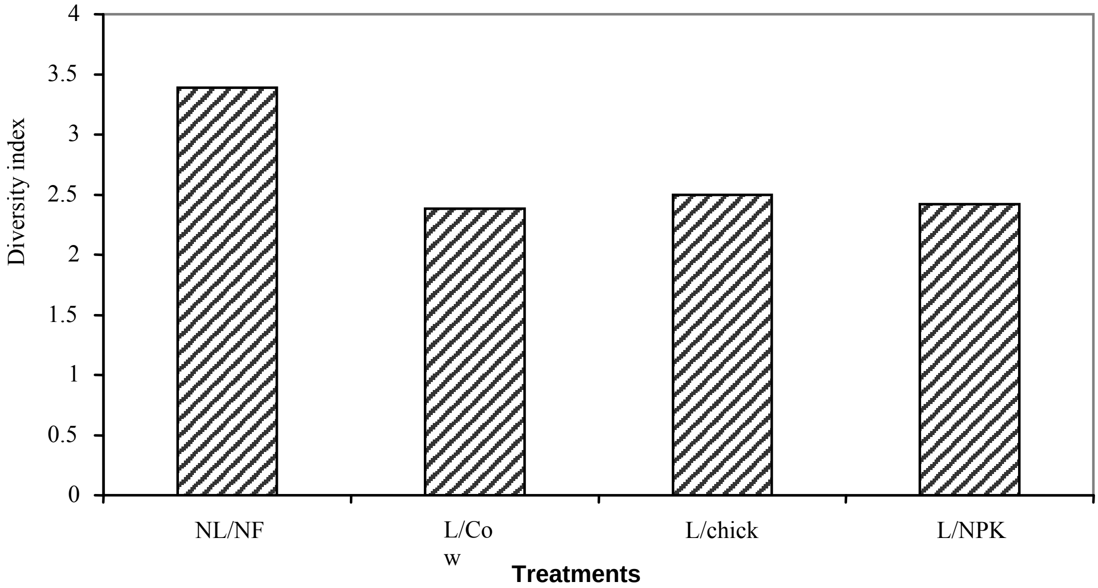


**Fig. 1. Diversity indices of phytoplankton in the different treatments.**

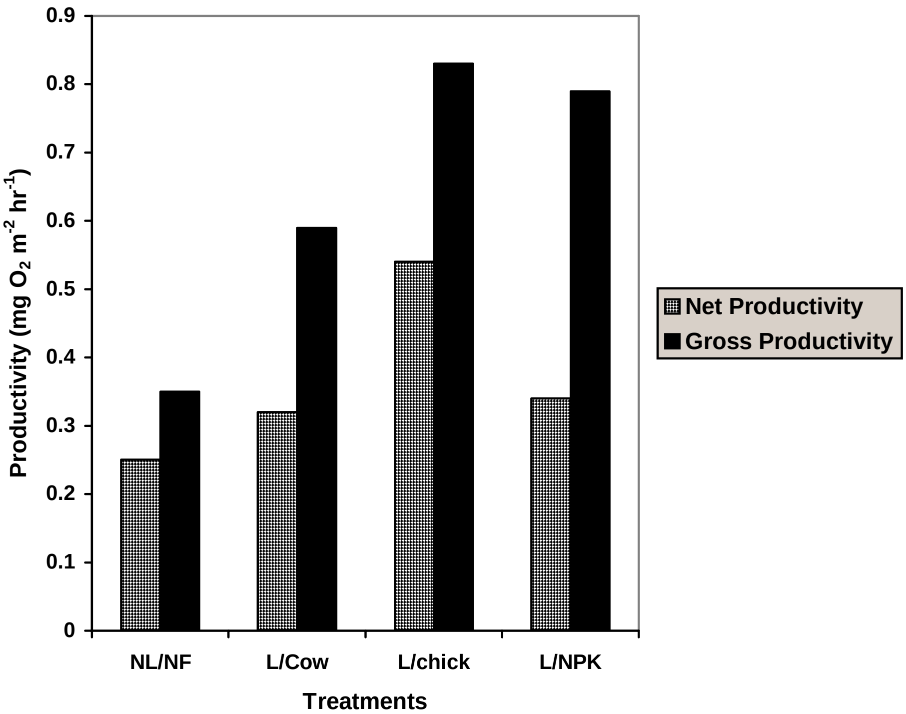


**Fig. 2. Primary productivity values in the different treatments.**

**Table 2. Distribution of phytoplankton species in relation to treatment**

| S/No. | CHLOROPHYTA | | NL/NF | L/COW | L/CHICK | L/NPK |
|---|---|---|---|---|---|---|
| 1 | *Scendensmus biiuga* | *(Turp) Lagehein* | ■ | ■ | ■ | ■ |
| 2 | *S. dispar* | *Breb* | | ■ | ■ | ■ |
| 3 | *S. denticulatus* | *Lagerheim* | ■ | ■ | ■ | |
| 4 | *S. ecornis* | *Chod* | | | ■ | ■ |
| 5 | *S. dimophus* | *Kuetzina* | | | | ■ |
| 6 | *S armatus* | *Chod* | ■ | | | ■ |
| 7 | *S. quadricauda* | *Chod* | ■ | | | |
| 8 | *Selenastrum westii* | *Smith* | | ■ | | ■ |
| 9. | *Pediastrum duplex* | *Meyen* | | | ■ | ■ |
| 10 | *P. simplex* | *Meyen* | ■ | ■ | ■ | |
| 11 | *Pleurosigma sp.* | *Meyen* | ■ | | ■ | ■ |
| 12 | *Ankistrodesmus falcatus* | *(Corda) Ralfs* | ■ | | | |
| 13 | *Tetraedon trigonum* | *(Naeg) Hansaira* | ■ | ■ | ■ | |
| 14 | *T. requlare* | *Hansaira* | ■ | | | |
| 15 | *T. minimum* | *Hans* | | ■ | ■ | |
| 16 | *Eustrum didelta* | *Turpin* | ■ | | | |
| 17 | *Ulothrix zonata* | *Kutzing* | ■ | | | ■ |
| 18 | *Coelastrum sphaericum* | *Nageli* | | ■ | | |
| 19 | *Chlamedomonas sp.* | *Ehr.* | | | ■ | ■ |
| 20 | *Pandorina sp.* | *Bony* | | ■ | ■ | ■ |
| 21 | *Chlorella vulgaris* | *Beijerinck* | ■ | | ■ | |
| 22 | *Cosmarum quadrum* | *Lundell* | | ■ | ■ | |
| 23 | *C. monomazum* | *Lundell* | | | ■ | ■ |
| 24 | *C. capense* | *De Toni* | ■ | ■ | | |
| 25 | *C. circulare* | *Reinsch* | ■ | ■ | ■ | |
| 26 | *Staurastrum orbiculare* | *Ralfs* | ■ | ■ | ■ | |
| 27 | *S. lanceolatum* | *Ralfs* | | ■ | ■ | |
| 28 | *S. sexcostatum* | *Breb* | ■ | ■ | ■ | ■ |
| 29 | *Closterium lanceolatum* | *Breb* | | ■ | ■ | ■ |
| 30 | *C. moniliferum* | *(Barry)Ehr* | ■ | ■ | | |
| 31 | *Spirogyra varians* | *(Hassal) Kutzing* | ■ | | | ■ |
| 32 | *Volvox aureus* | *Her* | ■ | ■ | | |
| 33 | *Anacystis incerta* | *(Lemm) Drouel and Daily* | ■ | | | |
| 34 | *Tabellaria fenstrata* | *(Lyngb) Kutzing* | | | | |
| | ***EUGLENOPHYTA*** | | | | | |
| 35 | *Euglena acus* | *Lemm* | | | | |
| 36 | *E. linnophita* | *Lemm* | ■ | | ■ | ■ |
| 37 | *E. Intermedia* | *(Klebs) Schmitz* | | ■ | | |
| 38 | *Phacus meson* | *Pochn* | ■ | | ■ | ■ |
| 39 | *C. accuminatus* | *Stokes* | ■ | ■ | | |
| 40 | *Trachelomonas volvocina* | *Ehrenbeng* | | ■ | ■ | |
| 41 | *Trachelomonas sp.* | *Her* | ■ | ■ | ■ | ■ |
| 42 | *T. congolense* | *ven Oye* | ■ | ■ | | |
| 43 | *Strombomonas ovalis* | *(Playf) Defl* | | ■ | | |
| 44 | *S. treubii* | *(Wolosz) Defl* | ■ | ■ | ■ | ■ |
| | ***CYANOPHYTA*** | | | | | |
| 45 | *Microcystis inserta* | *Kutzing* | | ■ | | ■ |
| 46 | *M. aeruginosa* | *Kutzing* | | | | |
| 47 | *Botryococcus brauni* | *Kutzing* | | | | |
| 48 | *Oscilatoria rubescens* | *de Candolla* | | ■ | ■ | ■ |
| 49 | *Coelosphaerium kuetzingianum* | *Nag* | | | ■ | |
| 50 | *Anabaena oscillaroides* | *Kleb* | ■ | | ■ | ■ |
| 51 | *A. viabilis* | *Kutzing* | | ■ | ■ | |
| | ***CHRYSOPHYTA*** | | | | | |
| 52 | *Cyclotella meneghiana* | *Kutzing* | ■ | | | ■ |
| 53 | *C. stelligera* | *Cl & Grun* | | | ■ | ■ |
| 54 | *Navicula similis* | *Krasske* | | | ■ | |
| 55 | *N. exiqua* | *Greg. Ex. Grun* | ■ | | | ■ |
| 56 | *N. gracilis* | *Ehr* | ■ | | | |
| 57 | *Melosira ambiqua* | *(Grun) Mill* | | ■ | | |
| 58 | *Pinnularia nobilis* | *Ehr* | ■ | | | |
| 59 | *Amphora lineolata* | *Ehrenbeng* | | | | ■ |
| 60 | *Gomphonema auqur* | *Her* | ■ | | | |
| 61 | *Diatoma hienale* | *Her* | ■ | | | |
| 62 | *Fragilaria capucina* | *Lyngb* | ■ | | | |
| | ***PYRROPHYTA*** | | | | | |
| 63 | *Glenodinium cinctun* | *Ehr* | | ■ | | ■ |
| 64 | *Hemidinium cinctum* | *Stein* | ■ | | | ■ |
| 65 | *Peridinium slaviense* | *Ehr* | ■ | | | ■ |
| 66 | *P. pulsilum* | *Ehr* | ■ | | ■ | |

1-19% Occurrence
20-29% Occurrence
40-59% Occurrence
60-79% Occurrence
80-100% Occurrence

This is probably so because when the environment is enriched with nutrients, the growth of the majority of species present at the time of fertilization is not usually enhanced, and according to Dickman and Efford (1972), a few previously rare species rapidly increase after fertilization to form a bloom and this striking increase in a few number of algal species usually results in a sharp reduction in the community diversity.

Both the net and gross productivity values were lowest in NL/NF where 0.25 and 0.35 mg $O_2$ $m^{-2}$ $hr^{-1}$ respectively, were obtained while higher values were obtained for the fertilized ponds. The significantly higher primary productivity obtained in fertilized ponds compared to the control shows the potential of fertilizers whether organic or inorganic, to increase pond productivity. The high productivity of chicken droppings is attributed the its chemical composition compared to cow dung and NPK.

## REFERENCES


Adeniyi, I. F. (1978). Studies on the physico-chemical factors and planktonic algae of Lake Kainji, Nigeria. Ph.D. Thesis, University of Ife, Ile-Ife, 460 pp

Akpan, E. R. and Okafor, N., (1996). On Organic fertilization and plankton development in two experimental freshwater ponds of Nigeria. *J. Aqua. Trop.* 12, 147-154.

APHA (1980). Standard methods for the examination of water and wastewater 12th ed,; AWA, WPCA.

Biswas, S. (1984). Phytoplankton of Opi Lake, Anambra State, Nigeria *Verh. Int. Verein. Liminol.,* 22, 1180-1184.

Biswas, S. and Neweze, N. O. (1990). Phytoplankton of Ogebule Lake, Opi, Anambra State, Nigeria *Hydrobiologia*, 199, 81-86.

Bold, H. C. and Wynne, M. J. (1978). Introduction to algae: Structure and reproduction. Bounty… Pretice-Hall Inc., Englewood Cliffs, New Jersey, 707 pp.

Boyd, C. E. (1982). Liming of fish ponds. *J. Soil and Water Cons.* 37(2), 86-88.

Dickman, M. and Efford, I. E. (1972). Some effects of artificial fertilization on enclosed plankton populations in Marion Lake, British Columbia *J. Fish. Res. Bd. Canada*, 29, 1595 – 1604.

Egborge, A. B. M. (1973) A preliminary checklist of the phytoplankton of the Oshun River, Nigeria F*reshwat. Biol*. 3, 569-572.

Egborge, A. B. M. (1977). The hydrology and plankton of Asejire Lake. Ph. D. Thesis, University of Ibadan, 286 pp.

Egborge, A. B. M. (1979). The distribution of phytoplankton and zooplankton in some Ibadan freshwater ecosystems. *Pol. Arch. Hydrobiol*. 26 (3), 323 – 335.

Ekpenyong, E. (1982). The physico-chemical quality of water in relation to primary production of fish ponds in Ile-Ife, Oyo State, Nigeria. M.Sc Thesis, University of Ife, Ile-Ife, Nigeria 190pp.

Ekpenyong, E. (1996). Physical and chemical factors and net phytoplankton distribution in some tropical fish ponds. *Trop. Freshwat. Biol.* 5, 43 – 53.

Fritsch, Y. (1975) Zur psychologie des fish-Schwarmes. *Die naturwissenschaften* 26, 601 –606.

Hickling, C. F. (1962). *Fish Culture*. Faber & Faber, London, 295pp.

Hutchinson, E. G. (1975) *A Treatise on Limnology and Chemistry of Lakes*. New York, J. Wiley and Sons, 654 pp.

Imevbore, A. M. A. (1967). Hydrology and plankton of Eleiyele Reservoir, Ibadan, Nigeria. *Hydrobiologia* 30, 154 – 176.

Imevbore, A. M. A. (1968). Planktonic algae of Eleiyele Reservoir. *Nig. J. Sc.,* 2, 85-90.

Kadiri, M. O. (1992). A comprehensive preliminary checklist of the algae of the Ikpoba Reservoir, Bendel State, Nigeria. *Hydrobiol. Bull*.,25, 309.

Margalef, R. (1971) Diversity. Pp 257-260. *In*: A Sournia (ed.) *Phytoplankton Manual.* UNESCO.

McArthur, R. H. and McArthur, J. W. (1961). On bird species diversity. *Ecology* 42, 594 – 598.

Needham, J. G. and Needham, P. R. (1978). *A guide to the study of freshwater biology*. 5th ed. Holden-Day, Inc., San Francisco, Calif., 94111, 108pp.

Ness, J. C. (1948). Development and status of pond fertilization in Central Europe. *Trans Am. Fish. Soc.* 76(1), 335-358.

Nwadiaro, C. S. and Ezefili, E. O. (1986) A preliminary checklist of the phytoplankton of New Calabar River, Lower Niger Delta. *Hydobiol. Bull.,* 19, 133-138.

Prescot, G. W. (1990). *How to know the planktonic algae.* Iowa, W. M. C. Brown Company Publisher 356 pp.

Swingle, H. S. (1947). Experiments on pond fertilization, *Ala. Polytech Inst. Agric Expt. Sta. Bull.* Alabama, 36 pp.

Thomaston, W. W. and Zeller, H. O. (1961). Results of a six year investigation of chemical soil and water analysis and lime treatment in Georgia fish ponds. *Proc. Ann. Conf. Southeast Game and Fish. Comm.* 15, 236-245.

Ward, B. H. and Whipple, C. G. (1959). *Freshwater biology* 2nd ed., W. T. Edmonson ed. New York, John Wiley & Sons Inc. 1247 pp.

Willoughby, L. G. (1976) *Freshwater Biology*, Ambleside, Cumbria, Freshwater Biological Association. 480 pp.

Zeller, H. D. and Montgomery, A. (1958). Preliminary Investigations of chemical soil and water relationships and lime treatment of soft water in Georgia farm ponds. *Proc. Ann. Conf. South-east Game and Fish. Comm.* 11, 71-76.