4. RESULTS

4.1. Field Experiment

4.1.1. First experiment (poly-culture management)

4.1.1.1. Physico - chemical analysis of water:

1- Water Temperature

Average of water temperature in all treatments started with about 26.4 C° at the beginning of the experiment and increased gradually to reach about 27.7 C° at September then started to decrease gradually to reach about 25.6 C° at October. There were no significant differences among all treatments ($P > 0.05$). Fig (1)

2- Dissolved Oxygen (DO)

Dissolved oxygen concentration fluctuated in small rang (7.5 – 8.8 mg/l) in all treatments throughout the experimental period. There were no significant differences among all treatments. Fig (2)

3- Sicchi Disk (SD)

Secchi-disk readings had a reverse relationship with both water temperature and DO. The highest values of secchi-disk readings was in the beginning of the experiment at July in all treatments especially in CF100 which was (16.4 cm), while the lowest value at September in all treatments especially CF300, it was about (11.0 cm). The differences between all treatments were not significant. Fig (3)

4- PH

The average pH values were almost stable throughout the experimental period till the end of experiment in October, the pH value averaged between 8.5 & 8.9 degree. There was no significant among all treatments. Fig (4)

5- Unionized ammonia (NH_3)

The highest NH_3 concentrations in all treatments were during September specially CF100 (0.4 mg/l), while the lowest ones were during October in all treatments specially CF200 (0.09 mg/l), however it was not significant. Fig (5)

6- Salinity

Salinity values were almost stable throughout the experimental period till the end of experiment in October. The average of salinity were 0.3 g/l. Fig (6)

7- Total alkalinity

Average of total alkalinity in all treatments had a tendency to decrease from the start of the experiment with about (322 mg/l) in (July) to the lowest average concentration (290 mg/l) in August and September where it has, then increase to be (329.5 mg/l) in October. The highest values of total alkalinity were in CF100 especially during July in the beginning of experiment. Fig (7)

8- Total Hardness

As illustrated in Fig (8) total hardness values in all treatments followed the same pattern of total alkalinity values where the average of total hardness in all treatments had a tendency to decrease from the start of the experiment with about (219 mg/l) in July to be the lowest (211 mg/l) in August and September, then increase to be (239 mg/l) in October. The highest values of total hardness were in CF100 especially during October.

9- Nitrite – N (NO_2-N)

Nitrite concentrations were near to stable throughout the experimental period till the end of experiment in October, CF100 had relatively more concentration than that in the other two treatments. Nitrite overall average was 0.06 mg/l in all treatments with no significant difference between all treatments. Fig (9)

10- Nitrate – N (NO_3- N)

The nitrate concentrations recorded the highest values at the beginning of the experiment in all treatments. The highest titrate concentration was in CF100 (0.8 mg/l) then nitrate concentration gradually decreased till reach the lowest values at September in all treatments. The lowest concentration record was in CF200 (0.47 mg/l), the concentration curve showed to be constant or slightly increase at the end of the experiment in October, however no significant difference obtained among treatments. Fig (10)

11- Orthophosphate

Orthophosphate concentration of CF100 had higher values than that in the other treatments thorough the experimental periods and it noticed that orthophosphate concentrations of CF100 and CF300 decreased and increased as paralleled lines both of them decreased gradually from the beginning of the experiment till reach the lowest values in September then slightly increased to the end of experiment while in CF200 concentration decreased till reach the lowest value in August then increased till pass the concentration of CF300 and near to the concentration of CF100 in the end of experiment. Orthophosphate concentration represented a high percentage of total phosphorus during September (62.0 %) while this percentage was (50.2 %) at the beginning of the experiment. Fig (11)

12- Total phosphorus

As shown in Fig (12) total phosphorus concentrations started to decrease from its highest values at the beginning of the experiment in July with an average of 1.16 mg/l to its lowest value at September (0.77 mg/l), then slightly increase at the end of the experiment in October with an average of (0.88mg/l). Total phosphorus in CF100 had higher concentration than those in the other treatments in overall experimental period.

4.1.1.2. Biological analysis of water

1-Phytoplankton dynamics

Phytoplankton species composition was presented in Table (4), with species subtotal and phytoplankton total count of all treatments through the experimental period, from Cyanophyceae (blue- green algae) division, *Microcystis* was the most abundant species while *Chlorella* was the most abundant species of Chlorophyceae (green algae) division followed by *Scenedesmus* however, the other phytoplankton divisions had no trend of abundant species. The overall average of phytoplankton count was tabulated in Table (5). CF100 treatment had the highest phytoplankton concentration while CF200 had the lowest phytoplankton concentration. Phytoplankton species composition with its percentage in each treatment was illustrated in Fig (13), the Chlorophyceae division was the most abundant division, its percent ranged between 53 - 67 % in all treatments.

The second most abundant division was Cyanophyceae (blue-green algae) in all treatment, while Bacillariophyceae was the third abundant division in all treatments.

As shown in Fig (14) Cyanophyceae species was fluctuated between its lowest concentration (7.26×10^6 org /l) in CF200 to its highest concentration (7.42×10^6 org /l) in CF100, however Chlorophyceae numbers closed to each other in all treatments with the highest concentration (29.7×10^6 org /l) in CF100 and the lowest concentration of (19.3×10^6 org. /l) in CF200.

2- Zooplankton

The zooplankton community illustrated in Table (6) and Fig (15a, 15b). The zooplankton population was dominated by the main groups namely Rotifera, Cladocera, Copepoda, Ostracoda and Nauplii. The highest group was rotifers especially in treatment (CF300) during October which was 558 Ind /L but the highest mean of rotifers group overall the periods was 251 Ind. /L in treatment

(CF200). Zooplankton community in treated ponds were 426, 361 and 352 Ind./l in (CF100, CF200 and CF300) respectively.

3- Total bacterial count

The highest average of total bacterial count in overall the periods of experiment found in treatment CF300 (62.99 x 10^2 CFU/ML). The count of bacteria in inlet canal was 25.00 x 10^2 CFU/ML in treated ponds while were 47.25, 59.96 and 62.99 x 10^2 CFU/ML in (CF100, CF200 and CF300) respectively. The total bacterial count illustrated in Table (7) and Fig (16).

4.1.1.3. Proximate analysis of fish

Analysis of variance indicated that percentages of crud protein, fat and ash in dry matter among the experimental treatments showed no significant. Average values of crude protein and fat contents in fish bodies for treatments CF100 was higher than those in the other treatments. The proximate analysis of the whole fish body for different treatments at the end of the experiments illustrated in Table (8) and Fig (17).

4.1.2. Second experiment (mono-culture management)

4.1.2.1. Physico - chemical analysis of water:

1- Water Temperature

As illustrated in Fig (18) average of water temperature in all treatments was almost the same ($P > 0.05$) 28 C°, in July (at the beginning of the experiment) temperature was 27 C° increased to reach its beak in August (30 C°) then decreased gradually to reach its lowest value at October (26.5 C°).

2-Dissolved Oxygen (DO)

Average dissolved oxygen concentration in all treatments had a tendency to increase from the start of the experiment (July) to August and September where it had the highest average concentration (10 mg/l). DO reached its lowest concentration of 7.8 mg/l in October, average DO showed the lowest concentration in (T1) and the highest one in (T2), how-ever there was no significant difference among the treatments. Fig (19)

3- Secchi-Disk (SD)

The higher value of SD was in the beginning of the experiment (22 cm), while its lower value around (14 cm) recorded in August and September in all treatments. The SD readings increased to about (16 cm) at the end of the experiment. Although (T1) and (T3) had the higher and lower values, compared to the other treatments respectively, but the differences among treatments were not significant. Fig (20)

4- pH

PH values increased slightly in all treatments from an average of 8.1 in July to 8.7 in August, then pH values were almost stable throughout the experimental period till the end of experiment in October. Fig (21)

5- Unionized ammonia (N-NH_3)

As illustrated in Fig (22) NH_3 concentrations in all treatments followed the same pattern of pH values where NH_3 concentration increased from an average of 0.17 mg/l in the beginning of the experiment (July) to an average of 0.42 mg/l in August, then NH_3 values tended to be stable with slightly decreased values at the end of the experiment with an average of 0.27 mg/l. The average NH_3 concentration of (T1) and (T2) treatments were slightly lower than that in the other three treatments, however it was not significant.

6- Salinity and Electric Conductivity (EC)

Salinity values increased from the lowest value at the beginning of the experiment of 7.15 g/l to reach its highest values at the end of experiment of 7.52 g/l. Fig (23)

7- Total alkalinity

From Fig (24) it could be noticed that all treatments had a concentration of total alkalinity very close to each other with a tendency to decrease throughout the experimental period with an average of 883.9 mg/l and 758.6 mg/l at the beginning and the end of the experiment, respectively.

8- Total hardness

There were no significant differences among treatments in the overall average of total hardness. The concentration of total hardness was increased from an average of 634 mg/l in July to average of 673.1 mg/l in October. Fig (25)

9 -Nitrite – N (NO_2-N)

Nitrite concentrations fluctuated between increased and decreased values throughout the experiment with no trend and no significant difference among treatments, Fig (26). Nitrite overall average was ranged between 0.02 to 0.03 mg/l in all treatments.

10 - Nitrate – N (NO_3- N)

As shown in Fig (27) nitrate concentrations started to decrease from its highest values at the beginning of the experiment in July with an average of 0.325 mg/l to its lowest value at the end of the experiment in October with an average of 0.097 mg/l, however no significant difference obtained, the concentration of nitrate was ranged between 0.128 to 0.249 mg/l.

11- Orthophosphate

From Fig (28) it could be noticed that orthophosphate concentration decreased gradually from an average of 0.147 mg/l in the beginning of the experiment to 0.05 mg/l at the end of the experiment. Orthophosphate concentration represented a high percentage of total phosphorus in the beginning of the experiment reached to 52.5 % this percentage was gradually decreased to reach its lowest percentage (20 %) at the end of the experiment.

12- Total phosphorus

Mean concentration of total phosphorus reached its peak in August in all treatments with an overall mean of 0.47 mg/l then total phosphorus concentration was gradually decreased throughout the experimental time to reach its lowest concentration of an overall average of 0.26 mg/l. Fig (29)

4.1.2.2. Biological analysis of water

1-Phytoplankton dynamics

Phytoplankton species composition was Presented in Table (9) with species subtotal and total phytoplankton count of all treatments through the experimental period, from Cyanophyceae (blue- green algae) division, *Merismopedia* was the most abundant species followed by *Microcystis* while *Chlorella* was the most abundant species of Chlorophyta (green algae) division followed by *Tetrastrum* however, the other phytoplankton divisions had no trend of abundant species. The

overall average of phytoplankton count was tabulated in Table (10). Treatment (T2) had the highest phytoplankton concentration while (T4) had the lowest phytoplankton concentration.

Phytoplankton species composition with its percentage in each treatment was illustrated in Fig (30), it is obvious that Chlorophyceae (green algae) division was the most abundant division, its percent around 50 % in all treatments.

The second most abundant division was Cyanophyceae (blue-green algae) in all treatment except for (T5) it was Bacillariophyceae (diatoms), while Dinoflagellate was the least abundant division in all treatments except for (T1), it was Euglenophyceae .

As shown in Fig (31) Cyanophyceae species was fluctuated between its lowest concentration (5.3 x 10^6 org/l) in T5 to its highest concentration (11.3 x 10^6 org/l) in (T2), however Chlorophyceae members was close to each other in all treatments with the highest concentration (22.8 x 10^6 org/l) in (T2) and the lowest concentration of (14.8x 10^6 org /l) in (T4) .

2- Zooplankton

Zooplankton community illustrated in Table (11) and Fig (32a, 32b). The zooplankton population was dominated by the main groups namely Rotifera, Copepoda and Nauplii. The highest group was Rotifera, especially in treatment (T5) during July was 5135 Ind. /L. The highest mean of Rotifera group overall the periods was 2408 Ind. /L in treatment (T5). The total mean of all standing crop densities values of zooplankton population in T1, T2, T3, T4 and T5 were 545, 2380, 3383, 2763 and 3299 Ind. /L, respectively.

3- Total bacterial count

The total bacterial count illustrated in Table (12) and Fig (33). The highest number of bacteria was 65.00 x 10^2 CFU/ML in treatment (T2) during October and also the highest average of total bacterial count in overall the periods of experiment

found in treatment (T2) was 44.67 x 10^2 CFU/ML. The lowest average of total bacterial count was 12.33 x 10^2 CFU/ML in treatment (T1) during July and also the lowest average of total bacterial count in overall periods of the experiment was 23.58 x 10^2 CFU/ML in treatment (T1).

4.1.2.3. Proximate analysis of fish

The proximate analyses of the whole fish body for different treatments at the end of the experiments are illustrated in Table (13) and Fig (34). Analysis of variance indicated that the difference of percentages of dry matter (crud protein, fat and ash) in the whole body among the experimental treatments were significant. However the highest CP, lowest fat and lowest ash contents were obtained by treatment (T2) while the lowest CP, highest fat and highest ash contents were obtained by treatment (T1).

4.2. Batch experiment

4.2.1. Growth response of *Chlorella vulgaris* to various salinity concentrations

The organism was grown in normal growth conditions (on BBM at pH 7 followed a system of 14 light / 10 dark photoperiod cycle at temperature 25 °C ±2) under different salinity concentrations: 0, 2, 4, 6 and 8 g/L. The growth of the organism represented as cell number content was favored by aging of culture at all salinity concentrations. However, the growth was more intensive at low salinity concentration than the growth in higher salinity concentration.

Cell count

The cell number of *Chlorella* cells was high during exponential phase of the culture and still steady around the same level with slight gradual decrease at the end of incubation periods (8 days).

At low salinity concentration, Table (14) and Fig (35) the growth of the organism represented as cell number was intensive during culture life and increased up to the end of incubation periods (8 days). The cell count reached maximum in culture incubated under 0 g of saline. It amounted to 206 x 10^4 cells/ ml after 6 days of incubation from 8 days incubation in indoor cultures.

Table (14) Growth response of *Chlorella vulgaris* (count x 10^4/ml) to different Salinities

Salinity (g)	Times (Days)			
	2	**4**	**6**	**8**
0	48 a	112 a	206 a	198 a
2	42 b	96 b	180 b	182 b
4	32 c	58 c	98 c	86 c
6	28 d	36 d	42 d	41 d
8	23 e	19 e	12 e	8.5 e

Initial algal count x 10^4 /ml = 26

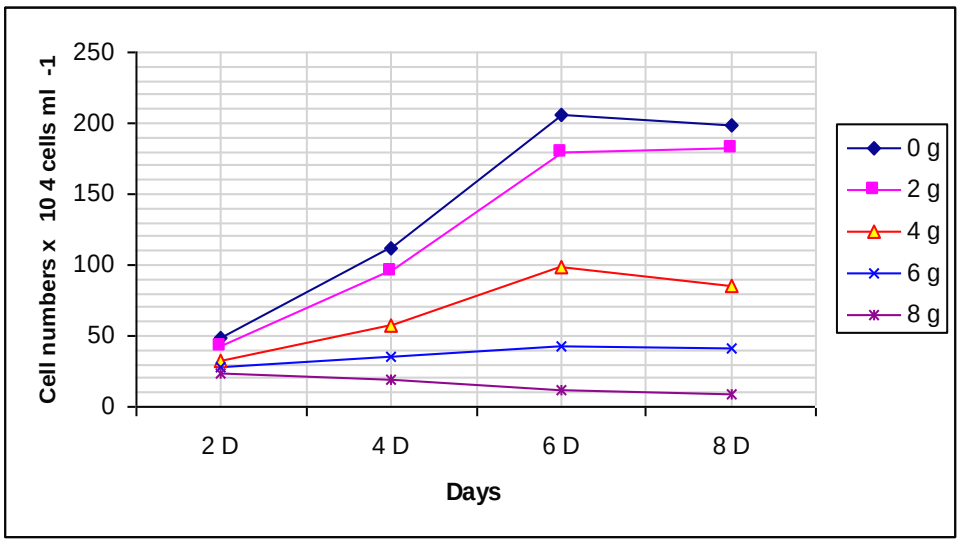


Fig (35): Effect of different salinity concentrations on cell numbers of *Chlorella vulgaris* at 2 days interval for a period of 8 days incubation in indoor cultures.

4.2.2. Growth response of *Chlorella vulgaris* to various light intensities

The organism was grown in normal growth conditions (on BBM at pH 7 followed a system of 14 light / 10 dark photoperiod cycle at temperature 25 °C ±2) under different light intensities: 2000 , 4000 , 6000, 8000 , and 10000 lux . Illumination for indoor *Chlorella* cultures is provided by fluorescent lambs which conducted by electricity timer. The growth of the organism represented as cell number content was favored by aging of culture at all light intensities. However, the growth was more intensive at high light intensities than low light intensities.

Cell count

The cell number of *Chlorella* cells was high during exponential phase of the culture and still steady around the same level with slight gradual decrease at the end of incubation periods (8 days).

At low light intensities as showed in Table (15) and Fig (36), the growth of the organism represented as cell number was intensive during culture life and increased up to the end of incubation periods (8 days). The cell count reached

maximum in culture incubated under 10000 lux. It amounted to 510.5 x 10^4 cells ml^{-1} at 6 days of incubation for a period of 8 days incubation in indoor cultures.

Table (15) Growth response of *Chlorella vulgaris* (count x 10^4/ml) to different light intensities

Light intensity (lux)	Times (Days)			
	2	**4**	**6**	**8**
2000	29.9 e	69.3 e	140.6 e	146.3 e
4000	39.5 d	92.2 d	228.0 d	227.2 d
6000	52.3 c	158.3 c	300.0 c	305.0 c
8000	61.4 b	190.7 b	345.3 b	313.3 b
10000	70.7 a	280.3 a	510.5 a	503.7 a

Initial algal count x 10^4/ ml = 15.5

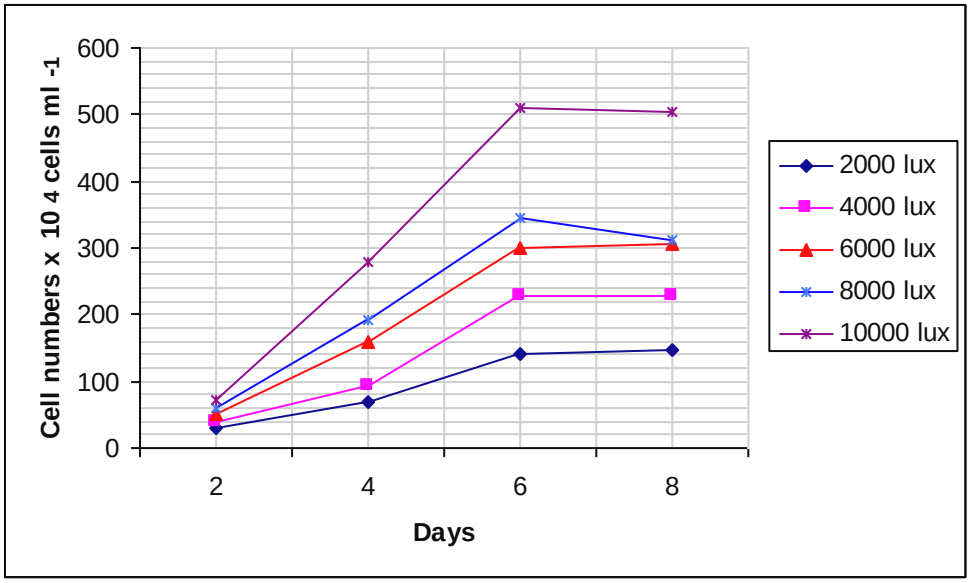


Fig (36): Effect of various light intensities on cell numbers of *Chlorella vulgaris* at 2 days interval for a period of 8 days incubation in indoor cultures.

4.2.3. Growth response of *Chlorella vulgaris* to various temperature degrees:

Growth of *Chlorella* at higher temperature was more intense than lower temperature. At 25 °C the growth of *Chlorella* was faster than at lower temperature. The relative high temperature (at 35 °C) led to a depression in growth

of Chlorella cells expressed as cell number compared with data obtained initially. Table (16) and Fig (37)

Cell count:

The cell number of *Chlorella* cultures incubated at 20 °C recorded maximum crop during the period of the day 6, of culture age which amounted to 312.3 x 10^4 cells / ml. The cell number at 25 & 30 °C reached highest rate at the 6 day of incubation periods which amounted to 289 and 145 x 10^4 cells ml-1, respectively.

Table (16) Growth response of *Chlorella vulgaris* (count x 10^4/ml) to different Temperature

Temperatures (°C)	Times (Days)			
	2	4	6	8
20	41.2 b	172.2 a	312.3 a	290.8 a
25	52.9 a	167.3 b	289.0 b	244.2 b
30	29.5 c	65.2 c	145.0 c	126.3 c
35	15.3 d	13.4 d	9.3 d	2.6 d

Initial algal count x 10^4 /ml = 21.6

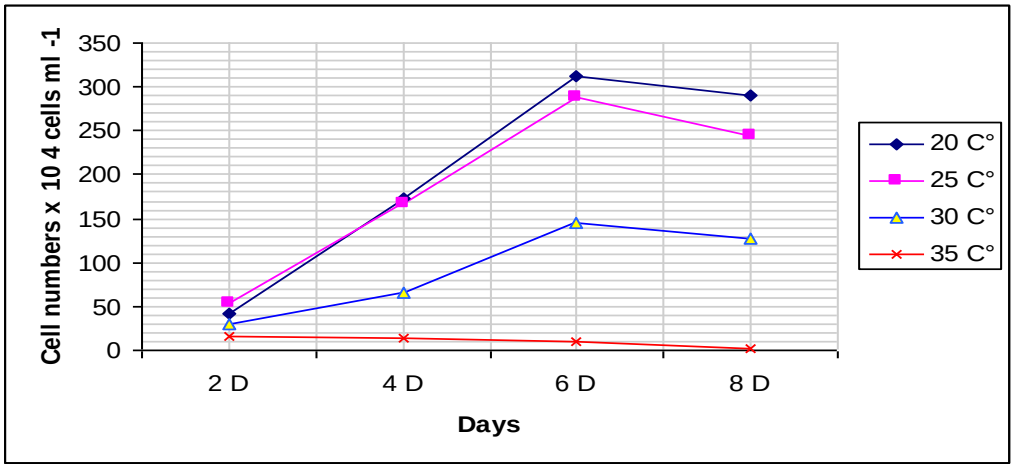


Fig (37): Effect of different temperature degrees on cell numbers of *Chlorella vulgaris* at 2 days interval for a period of 8 days incubation in indoor cultures.

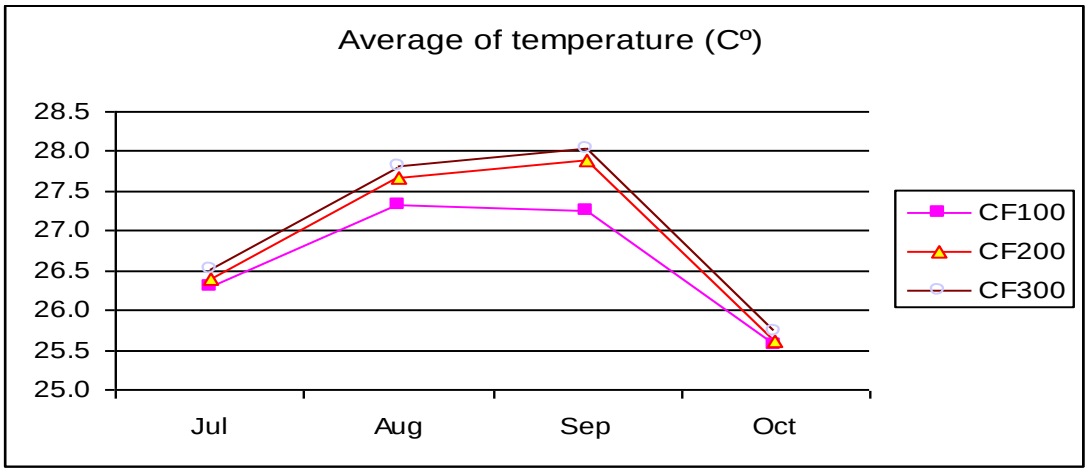


Fig (1): Average of water temperature (C°) in poly-culture fish ponds with different treatments.

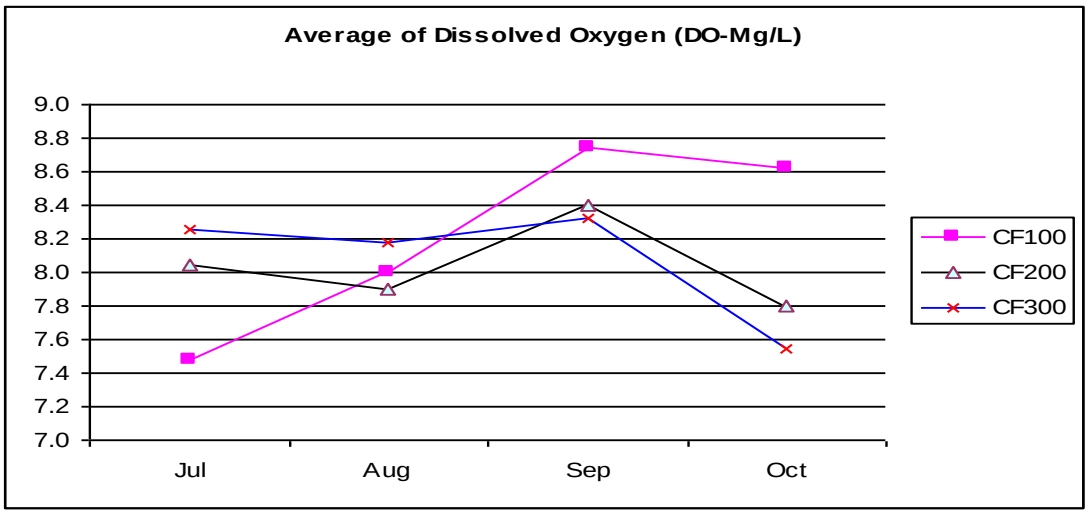


Fig (2): Average concentration of dissolved oxygen in poly-culture fish ponds with different treatments.

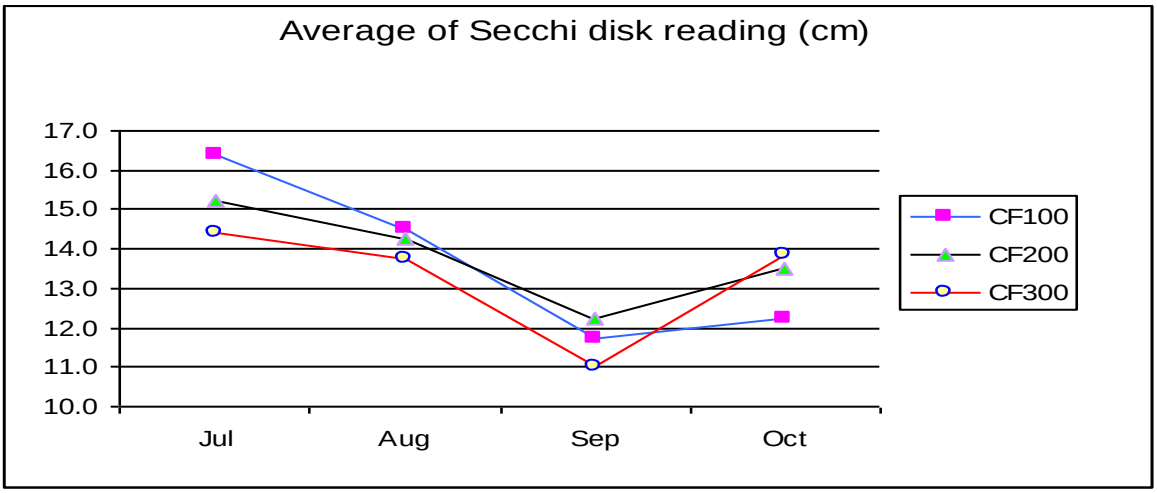


Fig (3): Average of secchi-disk readings in poly-culture fish ponds with different treatments.

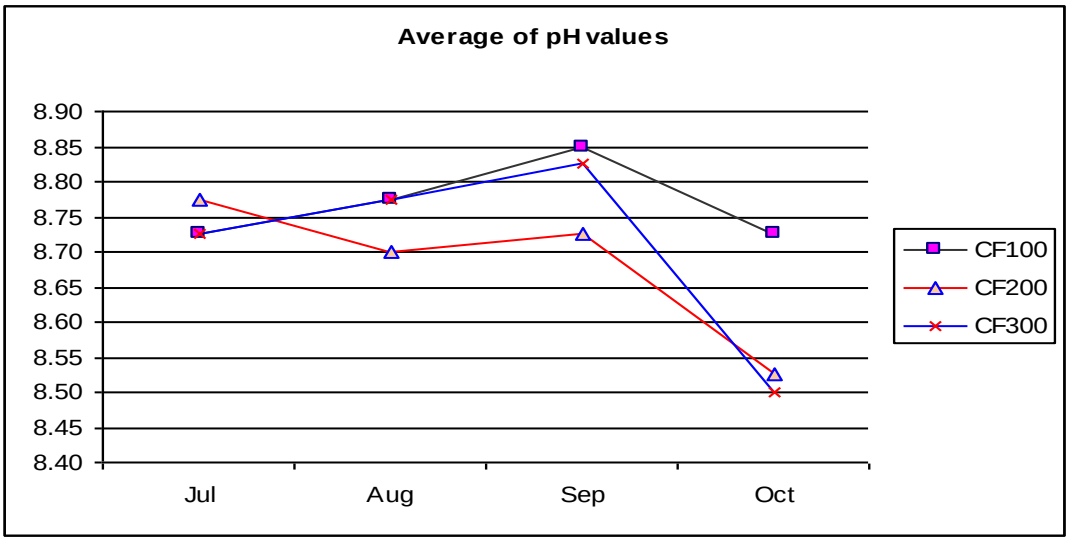


Fig (4): Average of pH values in poly-culture fish ponds with different treatments.

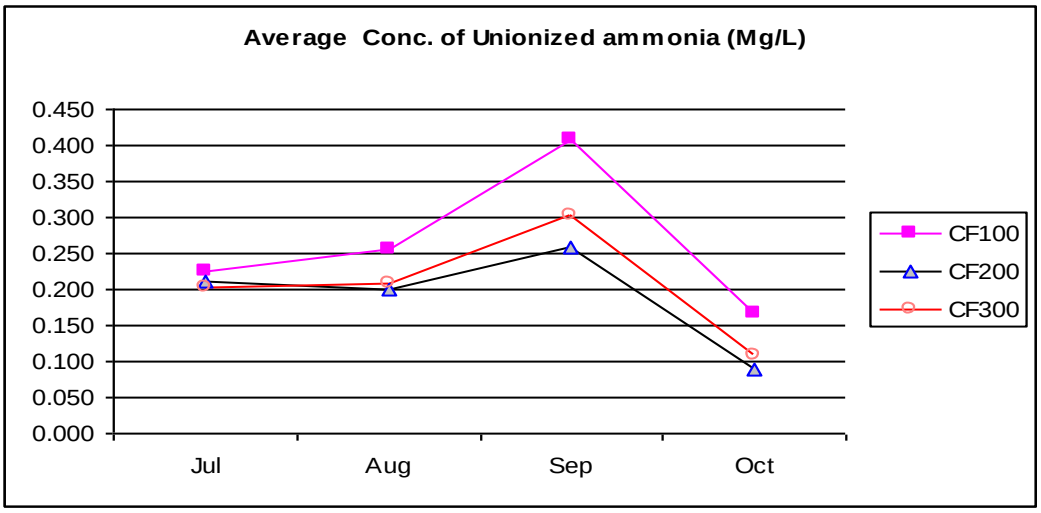


Fig (5): Average concentration of unionized ammonia (NH_3) in poly-culture fish ponds with different treatments.

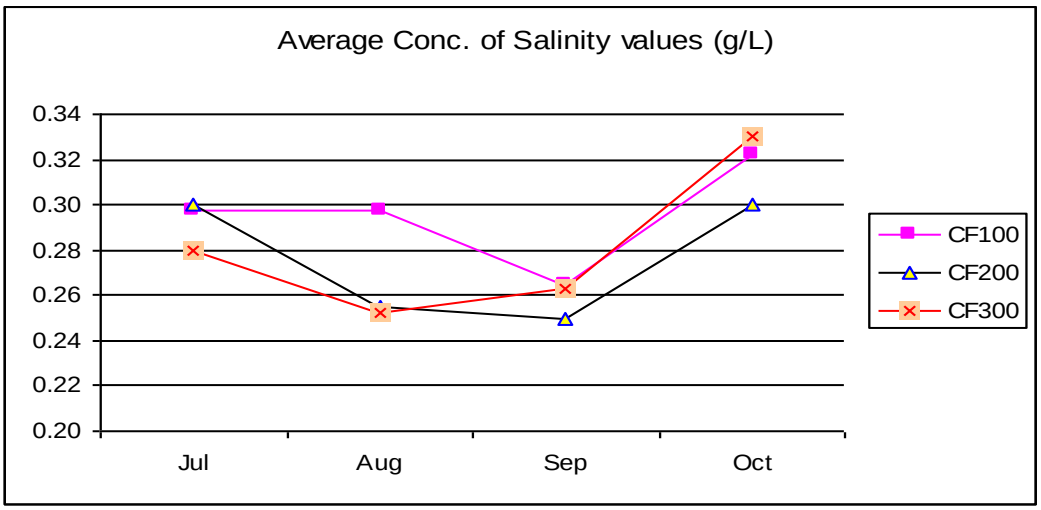


Fig (6): Average concentration of salinity values in poly-culture fish ponds with different treatments.

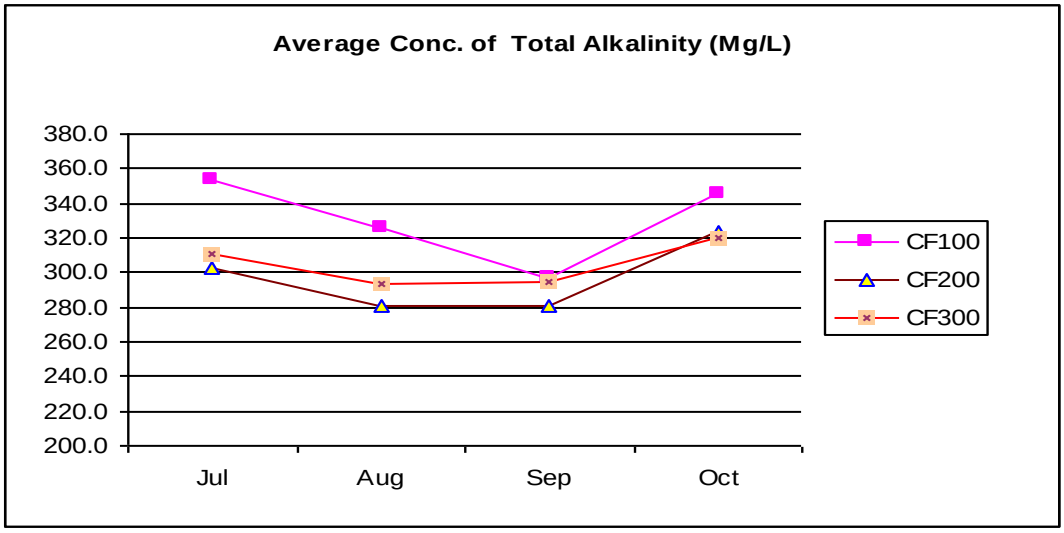


Fig (7): Average concentration of total alkalinity in poly-culture fish ponds with different treatments.

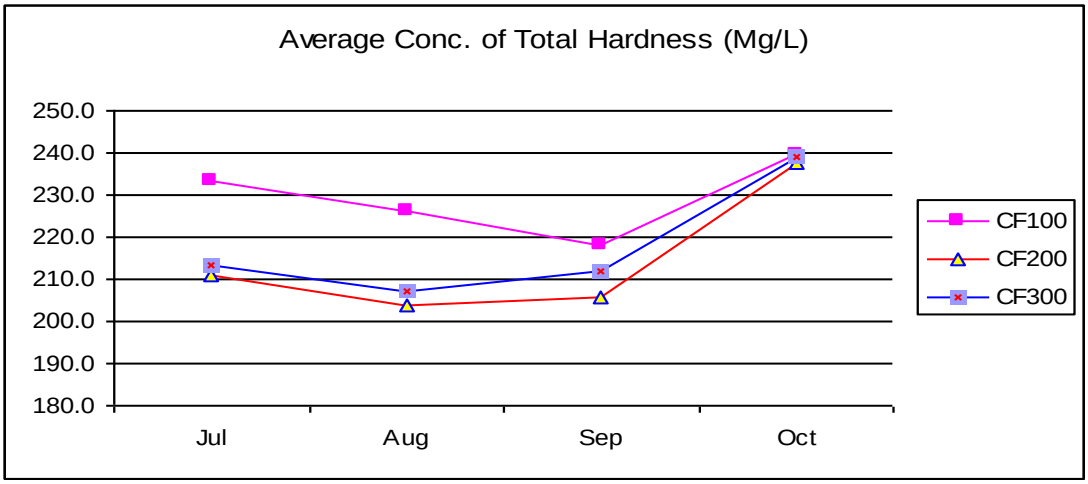


Fig (8): Average concentration of total hardness in poly-culture fish ponds with different treatments.

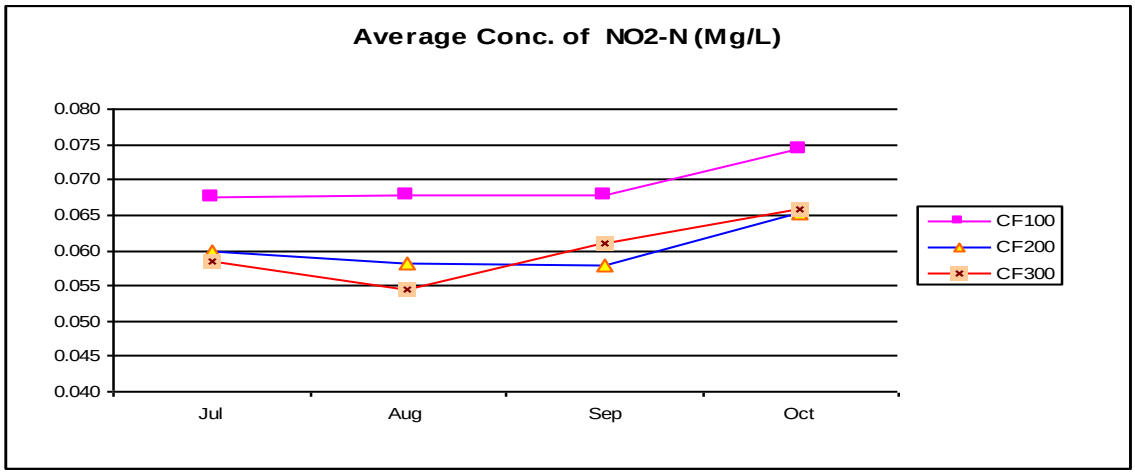


Fig (9): Average of nitrite concentrations in poly-culture fish ponds with different treatments.

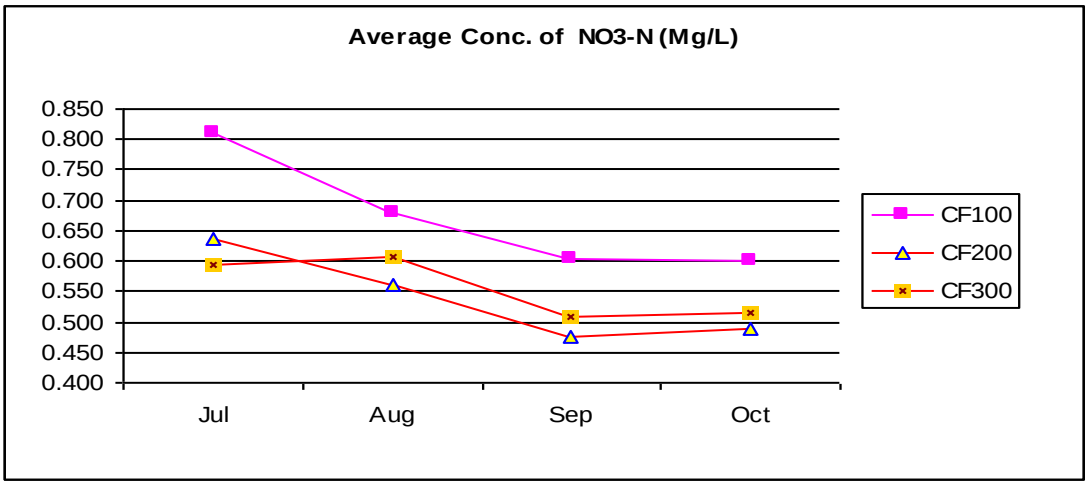


Fig (10): Average of nitrate concentrations in poly-culture fish ponds with different treatments.

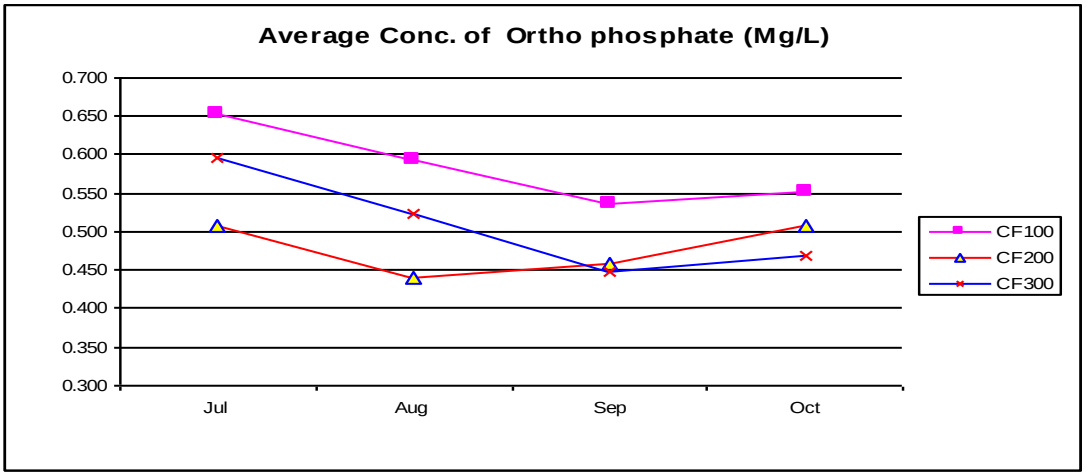


Fig (11): Average concentration of ortho phosphate in poly-culture fish ponds with different treatments.

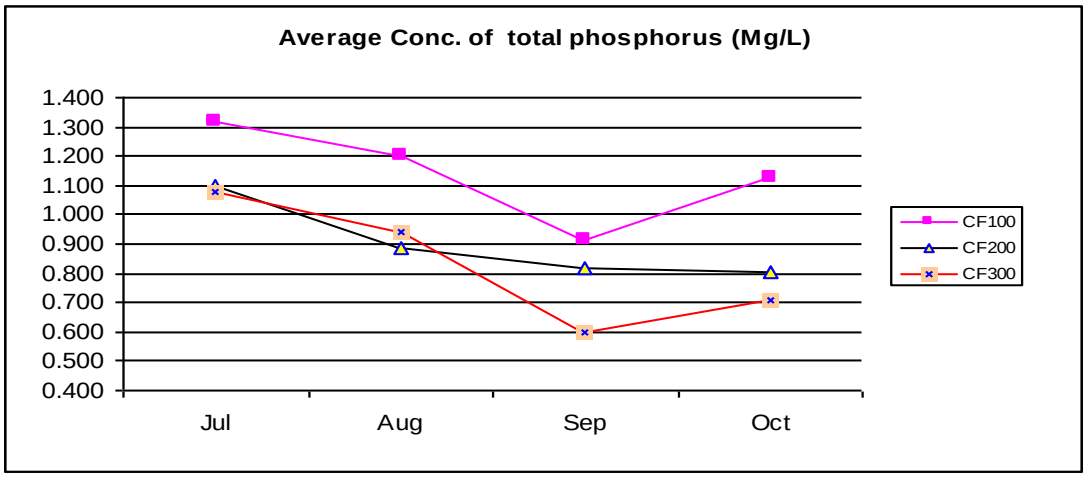
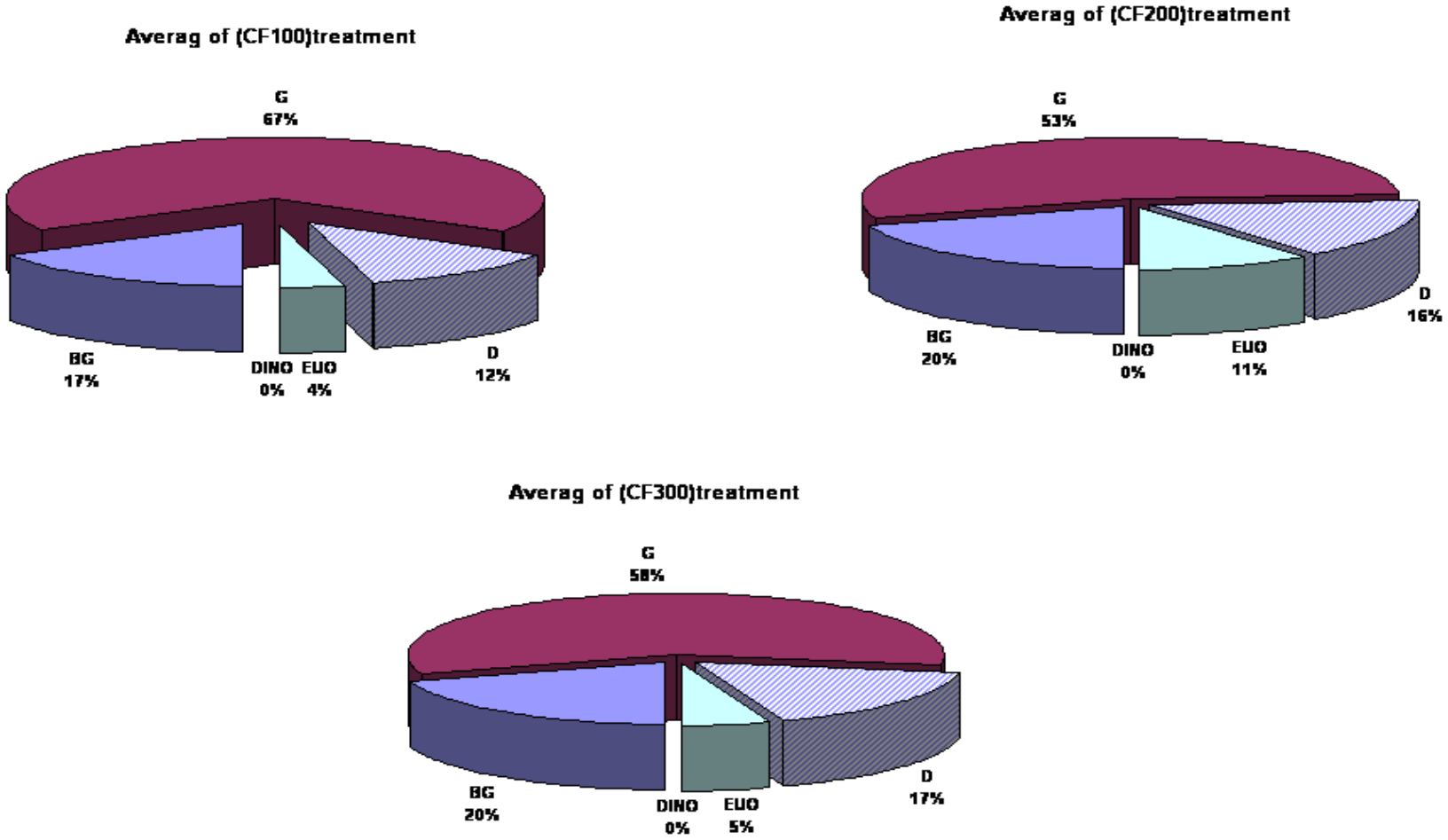


Fig (12): Average concentration of total phosphorus in poly-culture fish ponds with different treatments.



G : Green algae -- BG: Blue green algae -- D: Diatoms -- EUO: Euoglina -- DINO: Dinoflagellate

fig (13) Phytoplankton division composition with its percentage in poly-culture fish ponds with different treatments.

Table (5 a) Average of phytoplankton divisions in poly-culture fish ponds throughout the experimental period.

Month	Treatment	Cyano.	Chloro.	Bacill.	Eugl.
July	CF100	11,795,300	10,196,300	4,420,400	401,300
	CF200	6,195,000	11,389,000	2,161,200	516,000
	CF300	5,797,800	15,264,700	2,994,600	960,500
August	CF100	6,429,200	20,221,950	5,807,300	430,400
	CF200	6,670,675	13,693,225	1,772,700	1,950,000
	CF300	6,911,300	10,958,700	1,682,000	1,120,000
September	CF100	6,260,400	33,780,500	7,505,700	5,316,500
	CF200	11,432,810	19,267,400	12,077,500	10,875,220
	CF300	9,261,000	32,170,800	15,033,700	4,069,000
October	CF100	5,208,600	54,510,600	3,928,000	833,400
	CF200	4,745,100	32,824,000	6,976,000	1,883,000
	CF300	7,709,700	27,708,700	6,011,700	1,658,500

Table (5 b) overall average of phytoplankton divisions in poly-culture fish ponds with different treatments (Org X 10^3)

	Cyano.	Chloro.	Bacill.	Eugl.	Total count
CF100	7,423.4	29,677.3	5,415.4	1,745.4	44,261.46
CF200	7,260.9	19,293.4	5,746.9	3,806.1	36,107.21
CF300	7,420.0	21,525.7	6,430.5	1,952.0	37,328.18

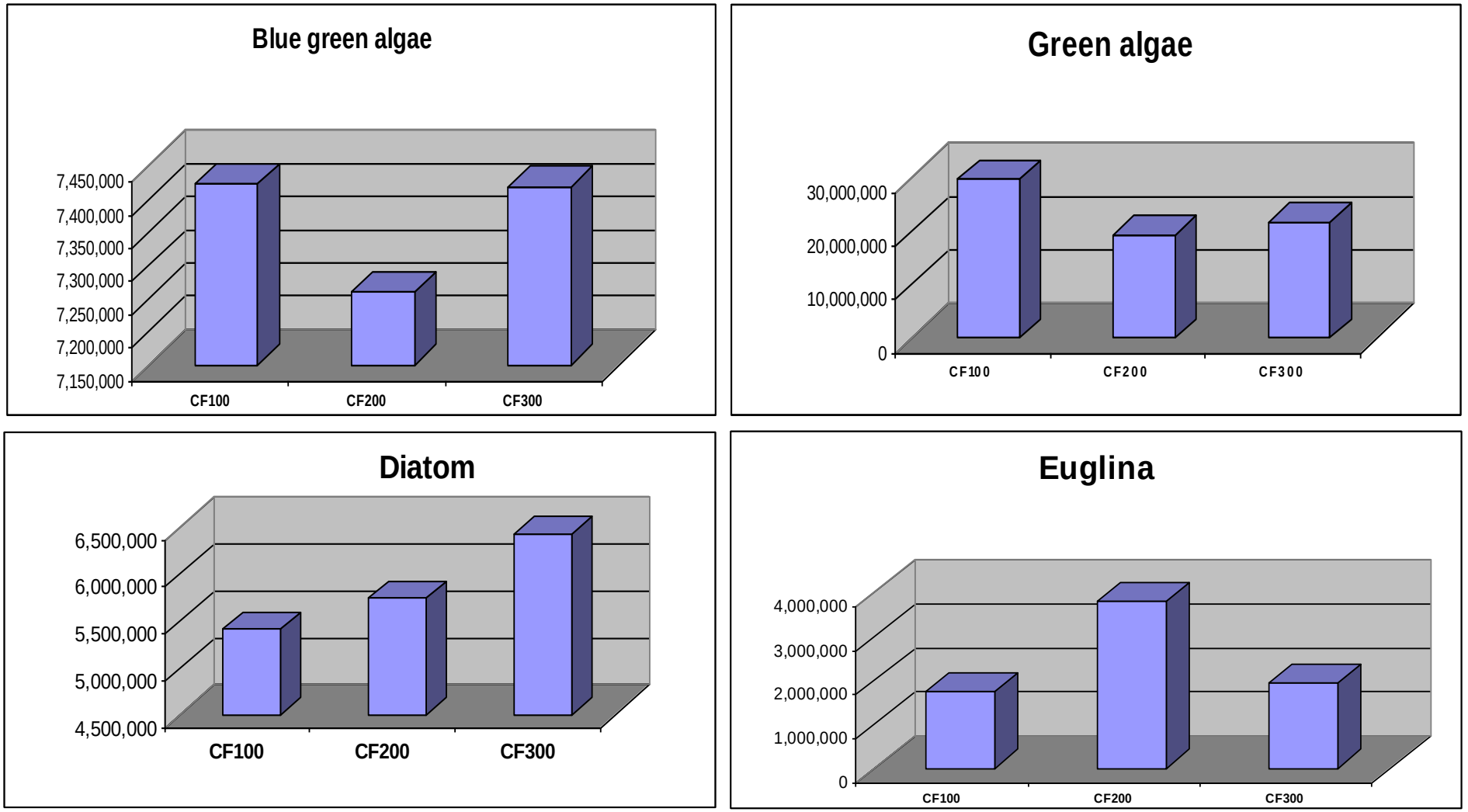


Figure (14) Average total count (org. x 10^5) of the most common phytoplankton division found in the water of poly-culture fish ponds

Table (6) zooplankton community in poly-culture fish ponds with different treatments during the experimental period

Month	Jul			Aug			Sep			Oct		
Treatment	CF100	CF200	CF300	CF100	CF200	CF300	CF100	CF200	CF300	CF100	CF200	CF300
Cladocera	58	42.5	32	161	86.5	29	56.5	38	41.5	0	8	13.5
Copepoda	51	30	44	52	69	23	13	9	31.5	189	30	36
Napuli	0	0	0	0	49.5	7	19	31.5	44	216	69	72
Rotefira	28.5	67	45.5	207	259	357	112.5	62.5	69	537	483	558
Ostrcoda	45.5	30	14.5	17.5	1	6	0	0	8	0	0	0
Total	183	169.5	136	437.5	465	422	201	141	194	942	590	679.5

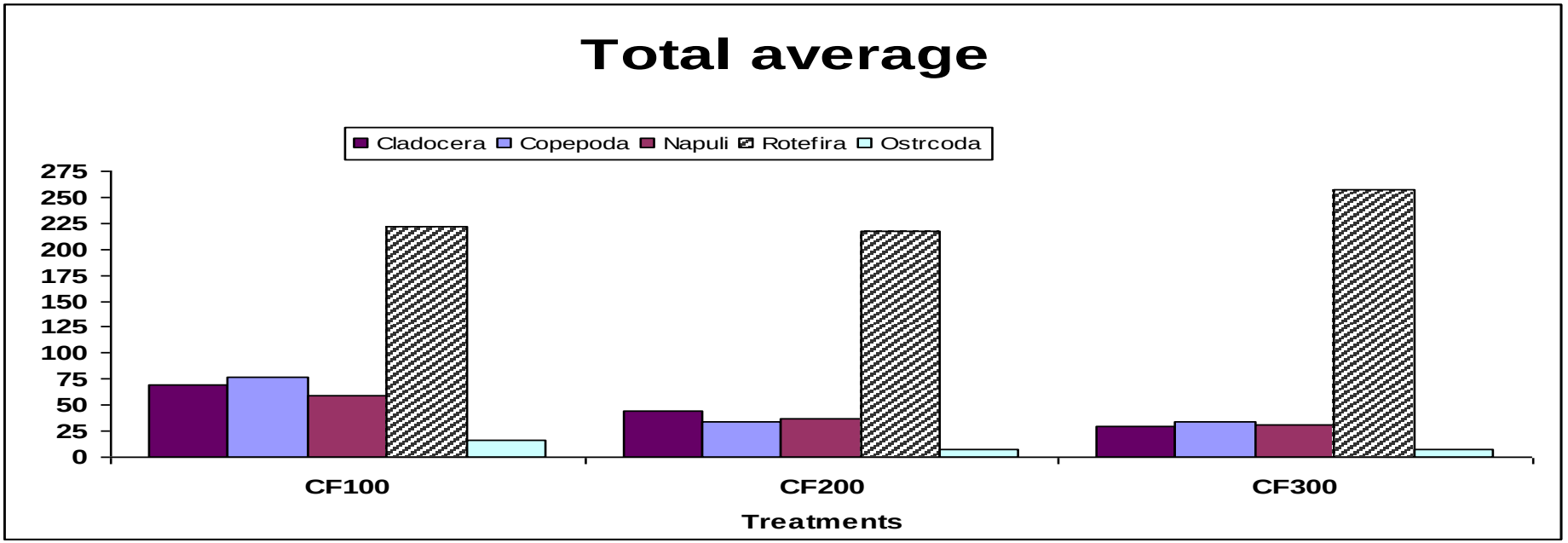


Fig (15b) zooplankton community in poly-culture fish ponds with different treatments during the experimental period

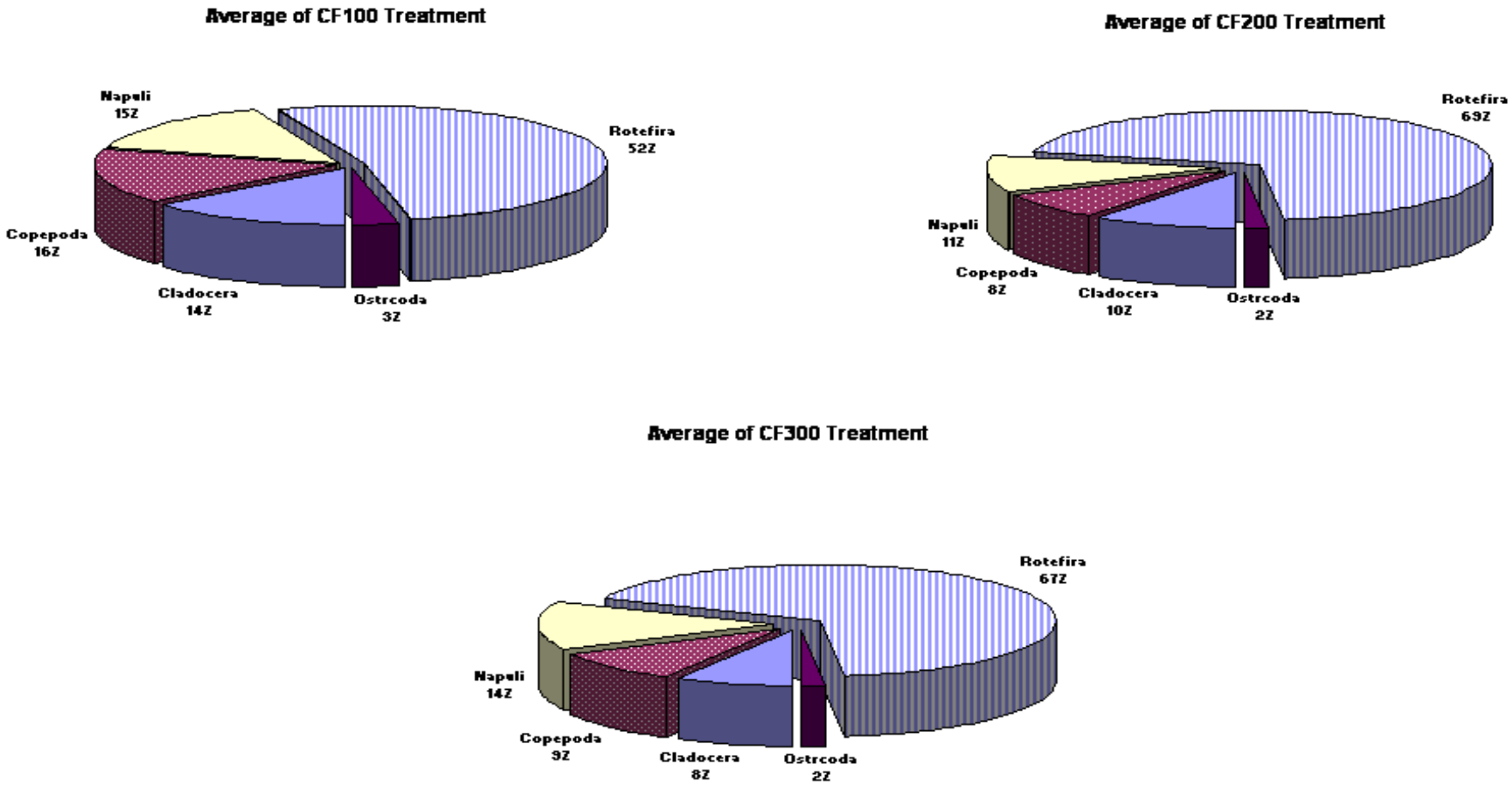


Fig (15a) zooplankton community in poly-culture fish ponds with different treatments during the experimental period

Table (7) Average of Total count of bacteria (T.C X 100) in poly-culture fish ponds with different treatments during the experimental period.

	Cf100	CF200	CF300
Jul	36.50 ^{b}±2.05	47.50 ^{b}±2.3	96.83 ^{a}±3.9
Aug	57.00 ^{a}±7	65.83 ^{a}±4.0	65.67 ^{a}±4.2
Sep	45.50 ^{b}±6.2	76.00 ^{a}±5.4	57.67 ^{ab}±5.8
Oct	50.00 ^{a}±5.2	50.50 ^{a}±6	31.80 ^{ab}±3.4
Average	47.25 ^{b} ± 4.8	59.95 ^{ab} ± 4.9	62.99 ^{a} ± 5.5

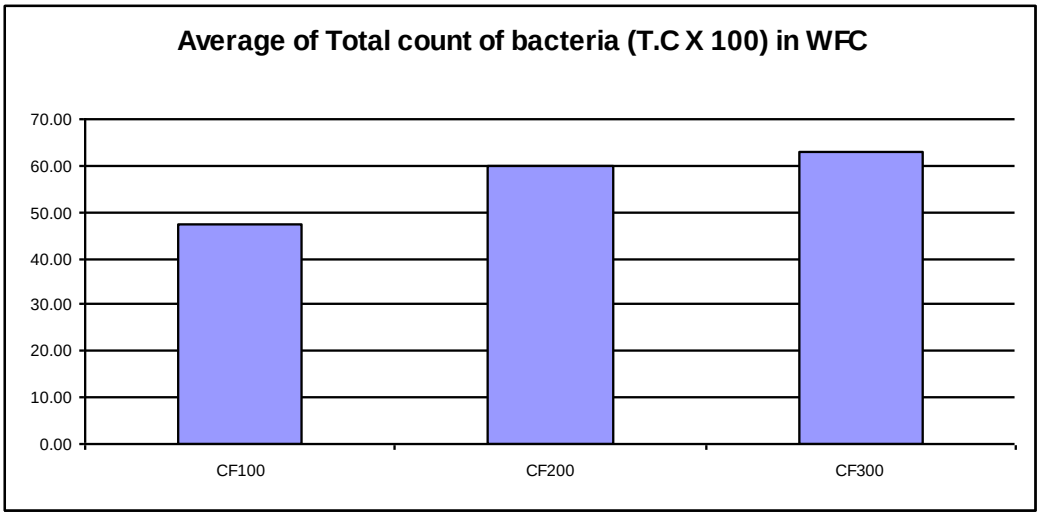


Fig (16) Average of total count of bacteria (T.C X 100) in poly-culture fish ponds with different treatments during the experimental period

Table (8) proximate analysis of the whole fish body of poly-culture fish ponds with different treatments at the end of the experiment.

	C	Cf100	CF200	CF300
DM %	84.115 ± 0.10	84.32 ± 0.07	84.85 ± 0.25	84.7 ± 0.20
CP %	64.165 ± 0.15	64.9 ± 0.29	64.7 ± 0.20	64.4 ± 0.46
FAT %	19.225 ± 0.08	19.76 ± 0.42	17.29 ± 1.33	19.6 ± 0.29
ASH %	16.61 ± 0.24	15.85 ± 0.21	16.01 ± 0.87	16 ± 0.75

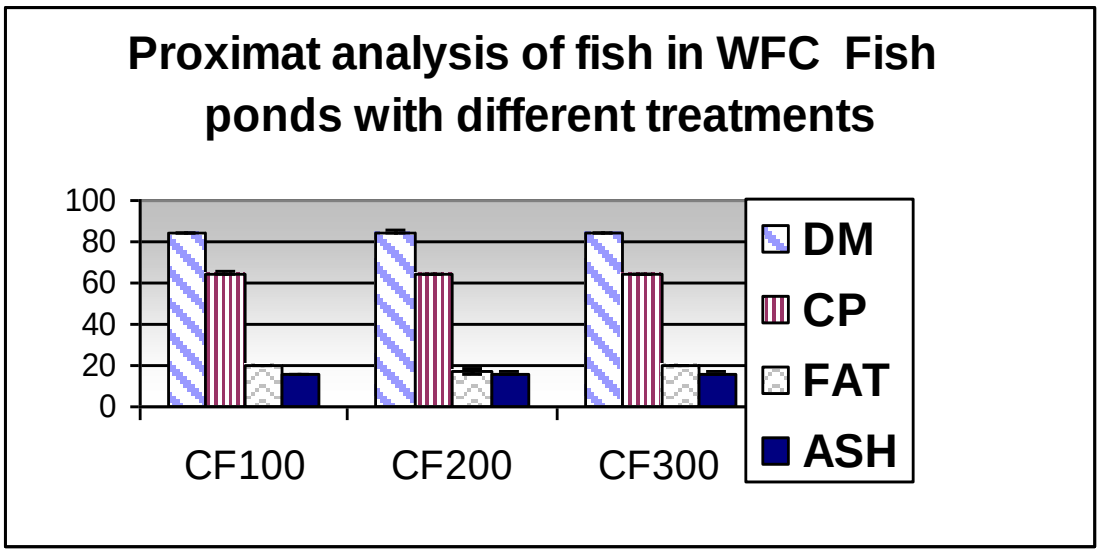


Fig (17) proximate analysis of the whole fish body of poly-culture fish ponds with different treatments at the end of the experiment.

Table (4) species composition of phytoplankton community in poly-culture fish ponds withdifferent treatments during the experimental period (Org x 1000)

	Jul				Aug				Sep				Oct			
Cyanophyceae	**CF100**	**CF200**	**CF300**	**C**	**CF100**	**CF200**	**CF300**	**C**	**CF100**	**CF200**	**CF300**	**C**	**CF100**	**CF200**	**CF300**	**C**
Microcystis SP.	7,394,400	4,781,000	3,596,500	61,200	4,556,200	2,836,000	3,681,700	2,177,500	3,752,000	5,004,000	6,592,500	2,073,667	2,708,600	2,613,100	5,000,400	2,151,000
Anabaena SP.	417,000	483,500	279,000	19,000	1,873,000	2,712,575	850,150	678,700	1,878,000	1,399,810	1,105,000	0	521,000	2,132,000	417,800	0
Merismopedia SP.	1,664,300	0	939,500	40,000	0	480,100	1,150,450	0	312,900	3,140,000	938,500	407,800	1,562,500	0	1,458,500	228,000
Aphanocapsa SP.	819,600	930,500	982,800	12,400	0	642,000	1,229,000	56,400	317,500	1,889,000	625,000	406,000	416,500	0	833,000	249,500
Cyano . subtotal	**10,295,300**	**6,195,000**	**5,797,800**	**132,600**	**6,429,200**	**6,670,675**	**6,911,300**	**2,912,600**	**6,260,400**	**11,432,810**	**9,261,000**	**2,887,467**	**5,208,600**	**4,745,100**	**7,709,700**	**2,628,500**
Chlorophyceae																
Tetraedron SP.	2,512,000	2,714,500	2,454,900	9,700	4,672,050	1,116,925	1,910,000	670,000	2,812,500	2,196,500	4,371,000	413,400	7,708,700	1,870,000	3,749,800	1,698,000
Scenedesmus SP.	4,559,000	3,334,400	4,449,700	31,600	3,188,800	972,900	1,820,000	995,000	7,517,000	2,821,600	6,542,500	812,528	9,583,500	5,000,000	2,708,100	1,239,000
Pediastrum SP.	0	527,500	807,600	0	636,000	1,270,000	1,236,000	610,600	626,500	940,000	2,191,500	419,900	416,900	1,234,000	1,041,700	237,500
Chlorella SP.	816,700	2,697,300	4,837,000	47,200	5,059,500	5,013,000	3,106,000	1,224,000	11,876,500	3,763,200	6,564,200	412,500	19,375,000	15,625,000	10,834,700	760,000
Ankistrodesmus SP.	214,900	511,000	239,500	0	569,500	905,000	375,000	632,600	2,187,500	2,178,000	1,562,100	0	3,467,500	1,875,000	1,249,400	0
Kirchnerilla SP.	290,800	522,000	1,405,500	18,300	4,630,500	1,887,500	1,277,000	642,500	6,252,000	5,018,000	7,505,000	406,200	11,146,500	5,000,000	5,208,000	247,000
Tetrastrum SP.	820,900	766,600	1,070,500	16,000	847,000	2,308,500	1,234,700	612,500	1,879,000	1,875,600	3,434,500	1,218,700	2,812,500	2,220,000	2,917,000	249,500
Errerella SP.	982,000	315,700	0	0	618,600	219,400	0	0	629,500	474,500	0	0	0	0	0	0
Chloro . subtotal	**10,196,300**	**11,389,000**	**15,264,700**	**122,800**	**20,221,950**	**13,693,225**	**10,958,700**	**5,387,200**	**33,780,500**	**19,267,400**	**32,170,800**	**3,683,228**	**54,510,600**	**32,824,000**	**27,708,700**	**4,431,000**
Bacillariophyceae																
Synedra SP.	0	1,041,600	206,900	18,200	823,400	0	0	655,000	1,564,500	2,834,000	4,990,000	402,333	0	625,000	835,500	0
Nitzchia SP.	1,215,700	474,000	1,105,000	19,900	3,168,900	1,289,800	1,052,000	1,875,000	3,439,300	8,439,500	7,187,500	406,300	1,979,000	4,379,000	3,125,700	247,700
Navicula SP.	2,793,400	312,900	1,199,700	0	0	0	630,000	522,500	1,249,700	312,000	983,100	413,000	521,500	1,245,000	623,500	690,000
Melosira SP.	0	332,700	483,000	19,500	0	0	0	1,294,500	1,252,200	0	933,500	8,163,670	1,427,500	0	1,047,000	9,585,000
Cyclotella SP.	411,300	0	0	11,000	1,815,000	482,900	0	761,200	0	492,000	939,600	814,667	0	727,000	380,000	499,800
Bacill . subtotal	**4,420,400**	**2,161,200**	**2,994,600**	**68,600**	**5,807,300**	**1,772,700**	**1,682,000**	**5,108,200**	**7,505,700**	**12,077,500**	**15,033,700**	**10,199,970**	**3,928,000**	**6,976,000**	**6,011,700**	**11,022,500**
Euglenophyceae (Phacus orbicularis)																
Eugl . Subtotal	**401,300**	**516,000**	**960,500**	**19,500**	**430,400**	**1,950,000**	**1,120,000**	**0**	**5,316,500**	**10,875,220**	**4,069,000**	**0**	**833,400**	**1,883,000**	**1,658,500**	**239,000**
Total count	**25,313,300**	**20,261,200**	**25,017,600**	**343,500**	**32,888,850**	**24,086,600**	**20,672,000**	**13,408,000**	**52,863,100**	**53,652,930**	**60,534,500**	**16,770,665**	**64,480,600**	**46,428,100**	**43,088,600**	**18,321,000**

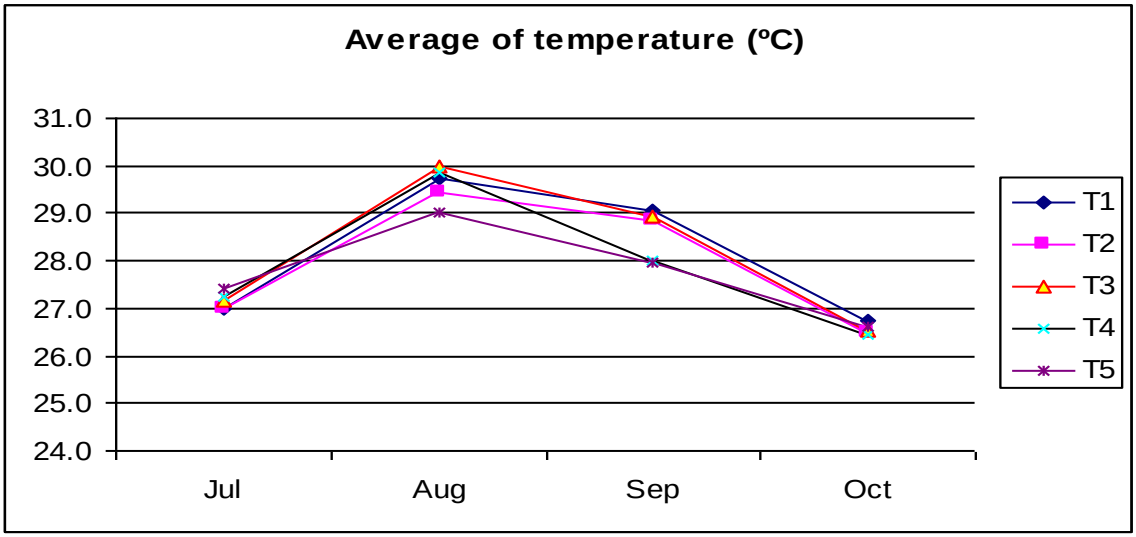


Fig (18): Average of water temperature (C°) in mono-culture fish ponds with different treatments.

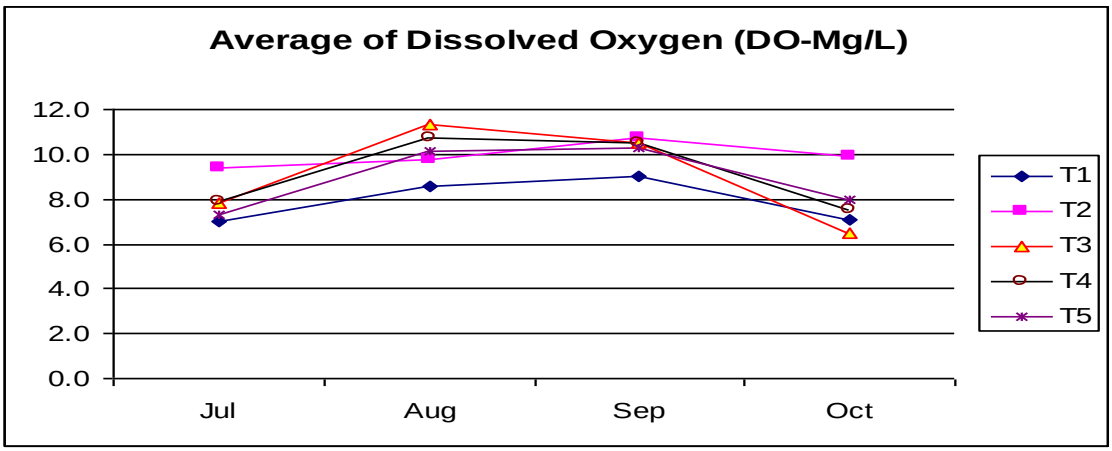


Fig (19): Average concentration of dissolved oxygen in mono-culture fish ponds with different treatments.

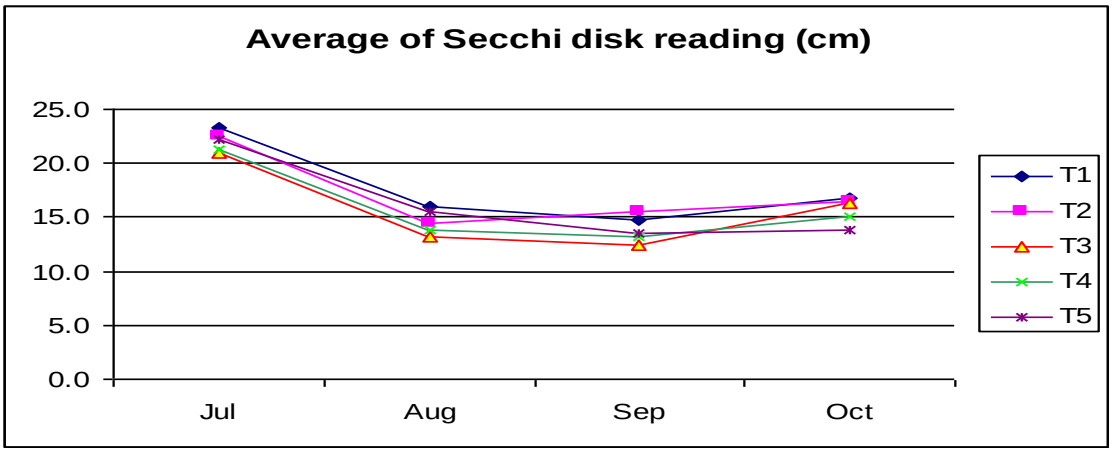


Fig (20): Average of secchi-disk readings in mono-culture fish ponds with different treatments.

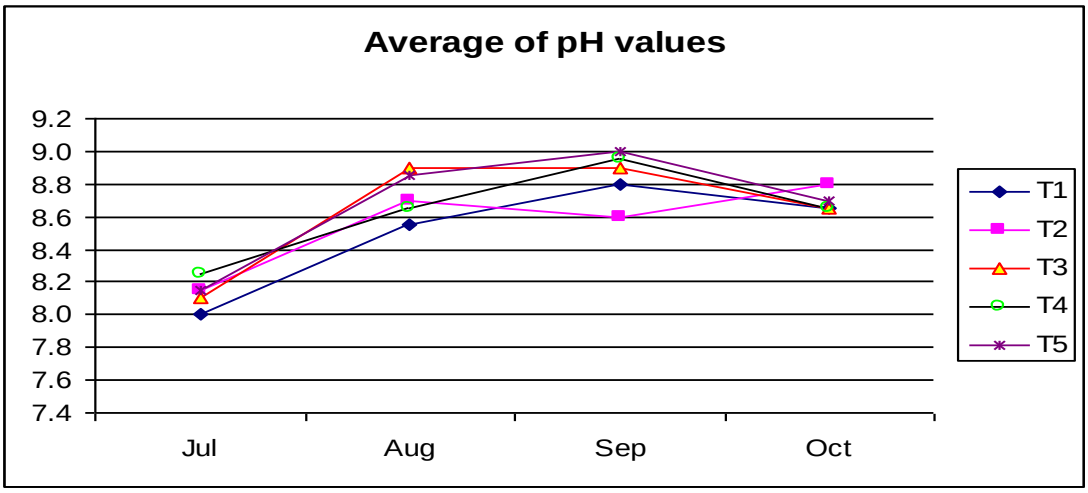


Fig (21): Average of pH values in mono-culture fish ponds with different treatments.

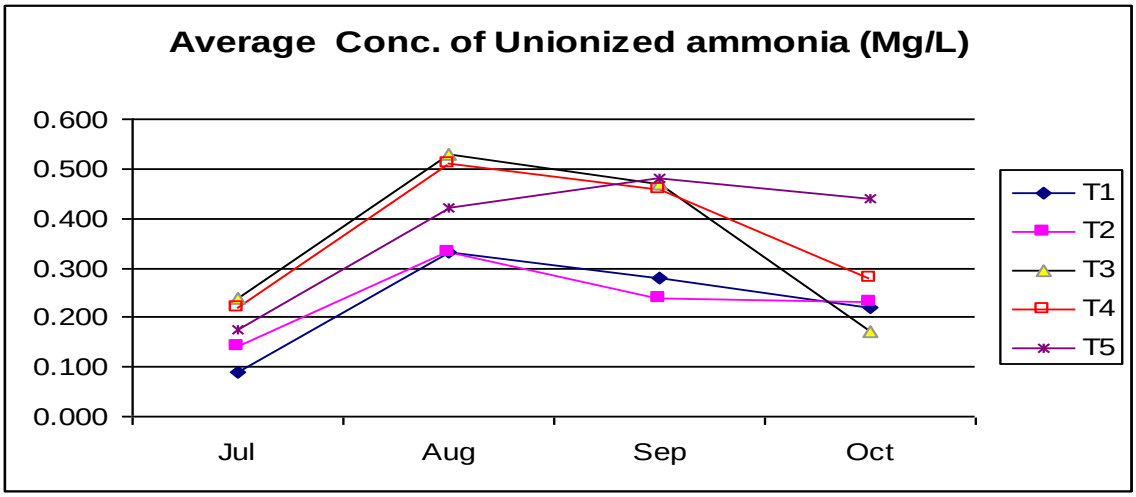


Fig (22): Average concentration of unionized ammonia (NH_3) in mono-culture fish ponds with different treatments.

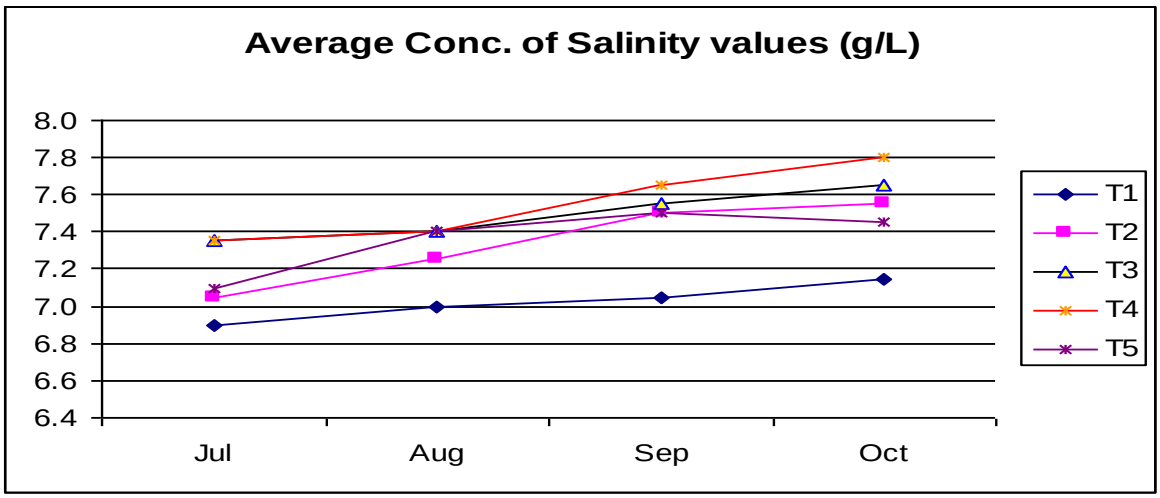


Fig (23): Average concentration of salinity values in mono-culture fish ponds with different treatments.

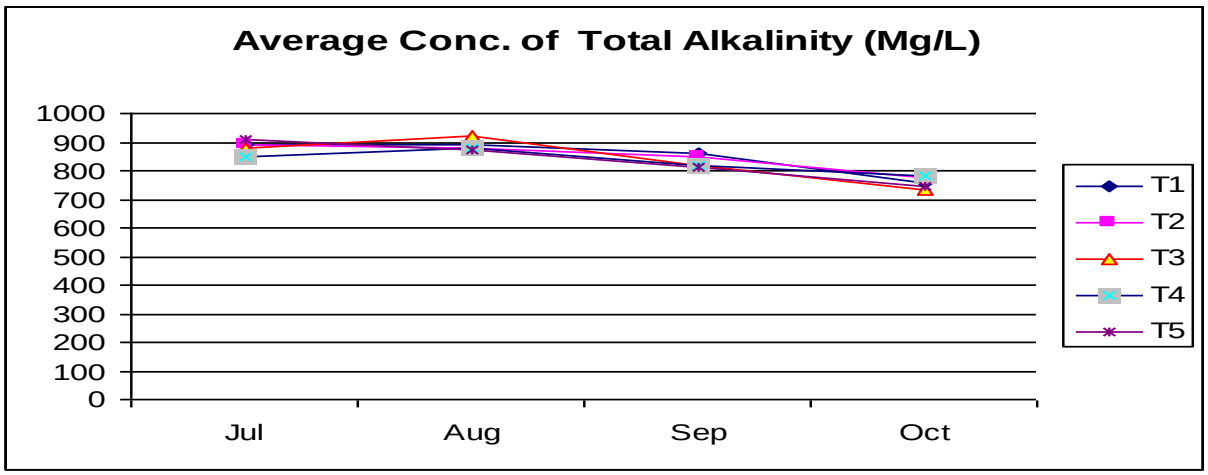


Fig (24): Average concentration of total alkalinity in mono-culture fish ponds with different treatments.

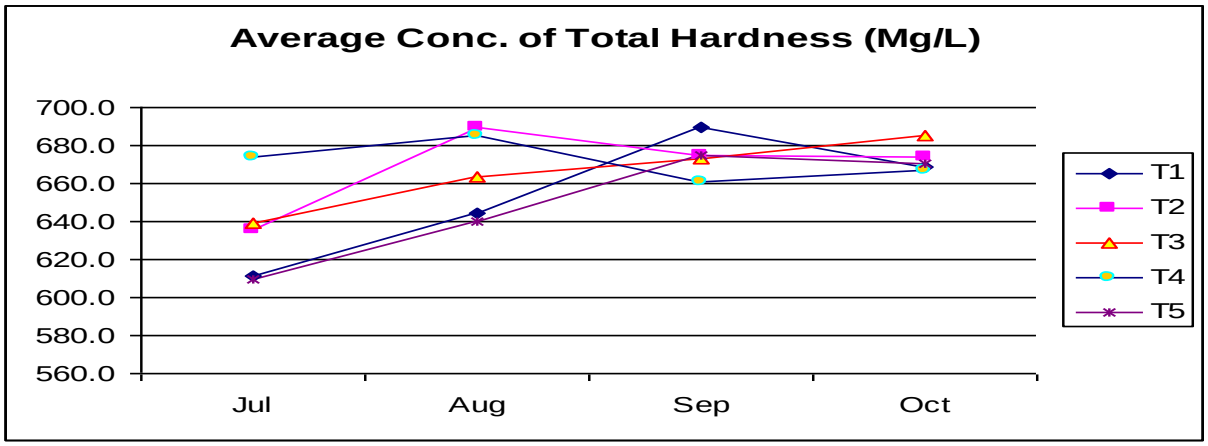


Fig (25): Average concentration of total hardness in mono-culture fish ponds with different treatments.

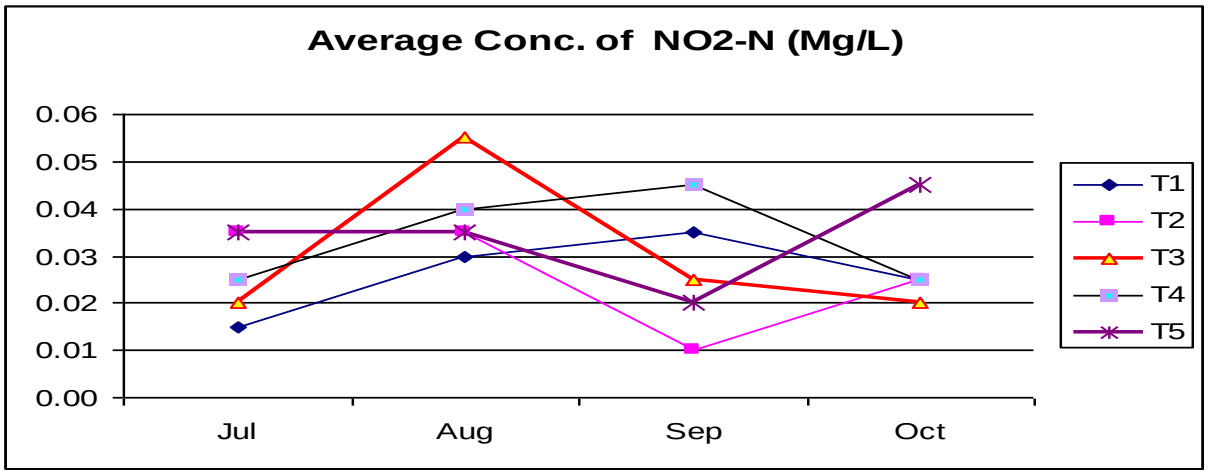


Fig (26): Average of nitrite concentrations in mono-culture fish ponds with different treatments.

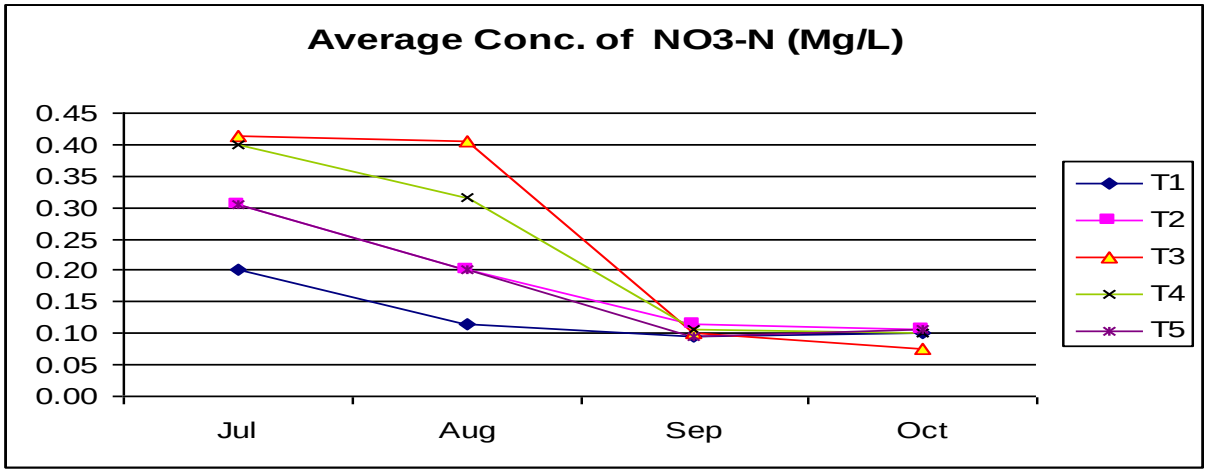


Fig (27): Average of nitrate concentrations in mono-culture fish ponds with different treatments.

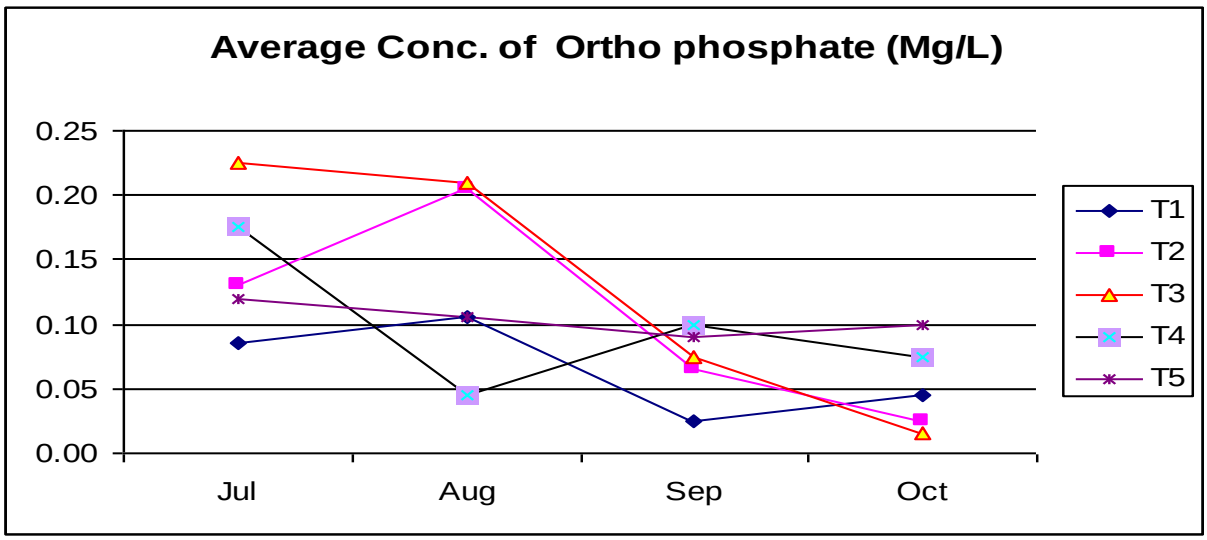


Fig (28): Average concentration of ortho phosphate in mono-culture fish ponds with different treatments.

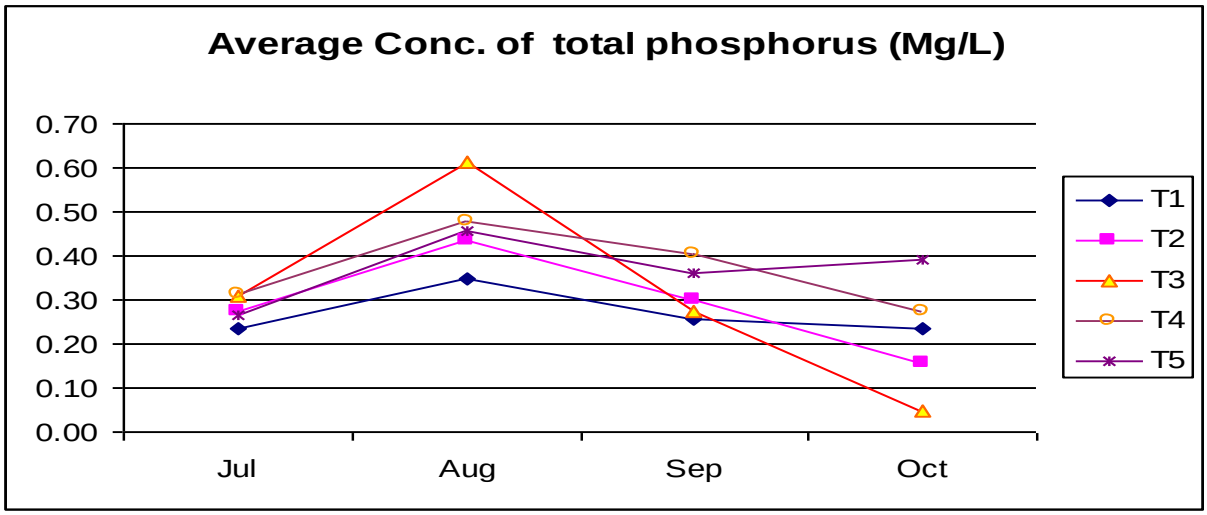
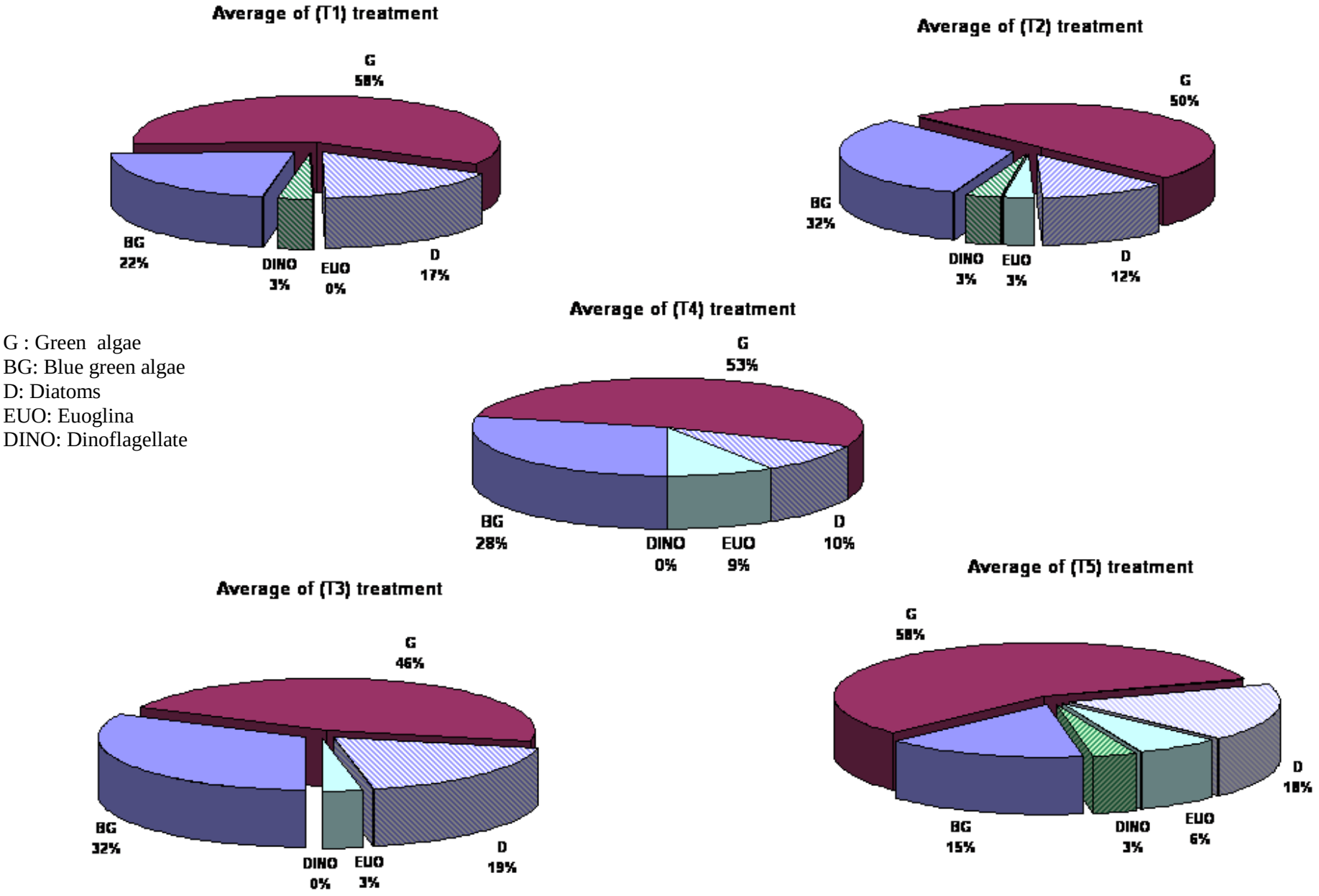


Fig (29): Average concentration of total phosphorus in mono-culture fish ponds with different treatments.



G : Green algae
BG: Blue green algae
D: Diatoms
EUO: Euoglina
DINO: Dinoflagellate

Fig (30) Phytoplankton division composition with its percentage in culture fish ponds with different treatments.

Table (10a) average of phytoplankton divisions in culture fish ponds with different treatments (Org X 10^3)

	POND	Cyano.	Chloro.	Bacill.	Eugl.	Dino.
July	T1	5,204,000	10,474,200	3,900,000	0	698,000
	T2	8,723,500	14,574,025	2,903,000	309,200	912,000
	T3	10,616,000	14,422,123	5,370,000	334,000	0
	T4	7,140,000	13,629,000	2,500,000	2,498,000	0
	T5	5,420,800	16,459,000	4,976,000	2,290,000	1,020,000
August	T1	5,870,800	13,042,000	4,305,000	0	934,000
	T2	12,012,000	28,827,200	4,120,000	1,268,000	1,229,600
	T3	11,168,600	15,681,260	6,124,125	1,222,000	0
	T4	7,810,000	14,360,000	2,738,000	2,690,000	0
	T5	5,772,800	19,025,400	5,553,000	2,120,000	1,108,000
September	T1	7,469,400	25,191,800	5,994,000	0	940,000
	T2	12,728,000	27,805,400	4,790,000	1,290,000	1,308,400
	T3	12,004,000	17,079,400	6,416,630	1,258,400	0
	T4	8,116,000	15,599,000	2,792,400	2,840,000	0
	T5	6,208,000	22,050,000	5,682,000	2,300,000	1,180,000
October	T1	7,300,400	21,040,200	5,758,000	0	1,040,000
	T2	11,708,000	20,141,600	4,940,000	1,168,000	1,280,000
	T3	9,740,000	14,988,400	7,716,000	1,270,400	0
	T4	8,469,000	15,538,000	2,800,000	1,780,000	0
	T5	3,724,000	20,392,000	7,988,200	2,040,000	1,152,000

Table (10b) overall average of phytoplankton divisions in culture fish ponds with different treatments (Org X 10^3)

	Cyano.	Chloro.	Bacill.	Eugl.	Dino.	Total count
T1	6,461.2	17,437.1	4,989.3	0.0	903.0	29,790.5
T2	11,292.9	22,837.1	4,188.3	1,008.8	1,182.5	40,509.5
T3	10,882.2	15,542.8	6,406.7	1,021.2	0.0	33,852.8
T4	7,883.8	14,781.5	2,707.6	2,452.0	0.0	27,824.9
T5	5,281.4	19,481.6	6,049.8	2,187.5	1,115.0	34,115.3

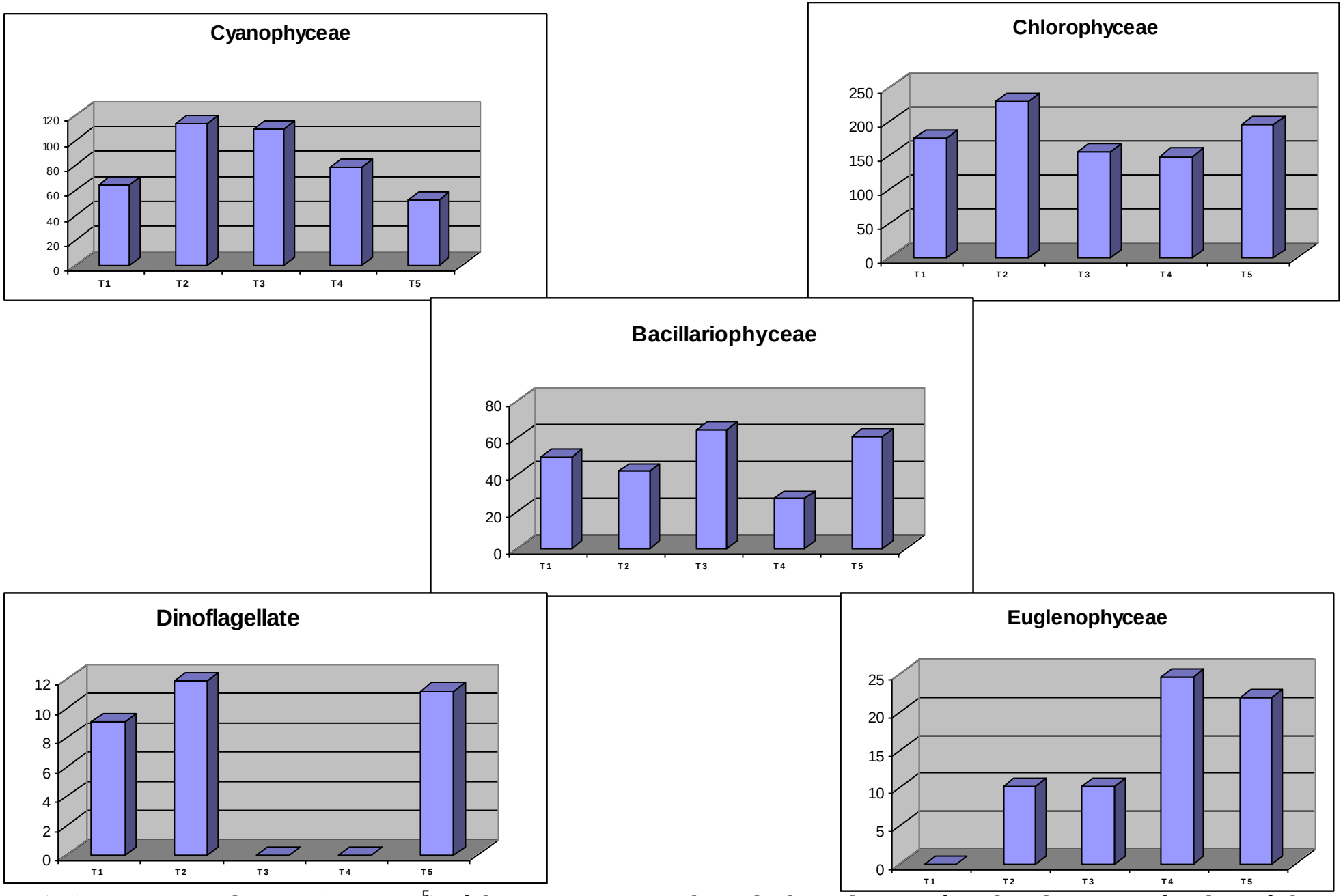


Figure (31) Average total count (org. x 10^5) of the most common phytoplankton division found in the water of culture fish ponds in five treatments.

Table (11) zooplankton community in mono-culture fish ponds with different treatments during the experimental period

Month	Jul					Aug					Sep					Oct				
Treatment	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Copepoda	39	168	60	130	104	95	850	2025	688	527	41	68	338	257	162	14	27	135	95	108
Napuli	52	192	40	80	286	176	2362	2038	1701	1485	41	162	851	635	608	27	121	378	310	284
Rotefira	156	3840	1350	3670	5135	635	513	1472	621	2767	607	594	2551	1310	986	297	621	2295	1553	743
Total	247	4200	1450	3880	5525	906	3725	5535	3010	4779	689	824	3740	2202	1756	338	769	2808	1958	1135

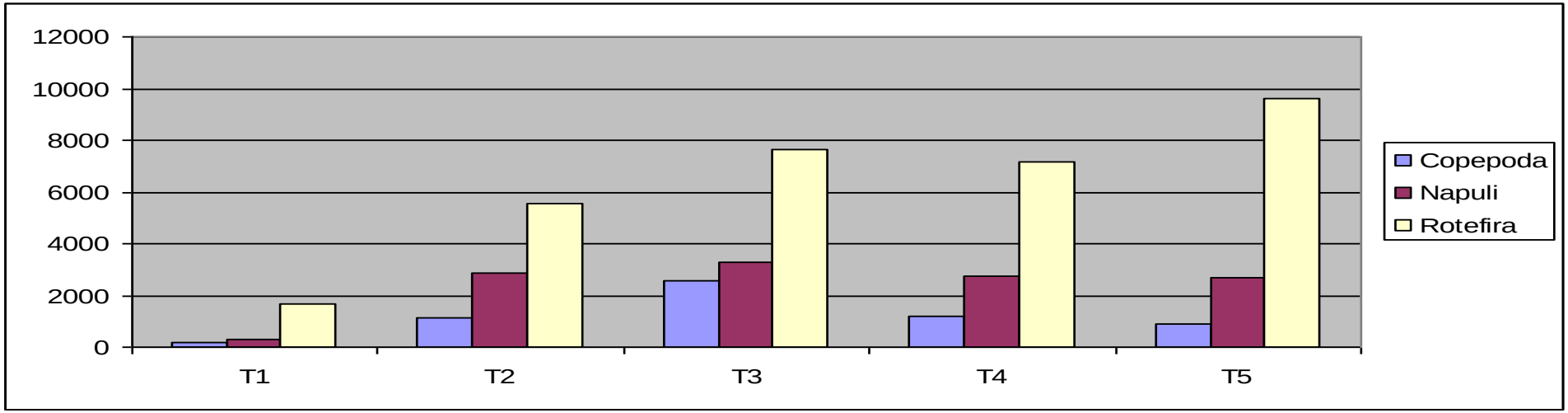


Fig (32a) zooplankton community in mono-culture fish ponds with different treatments during the experimental period

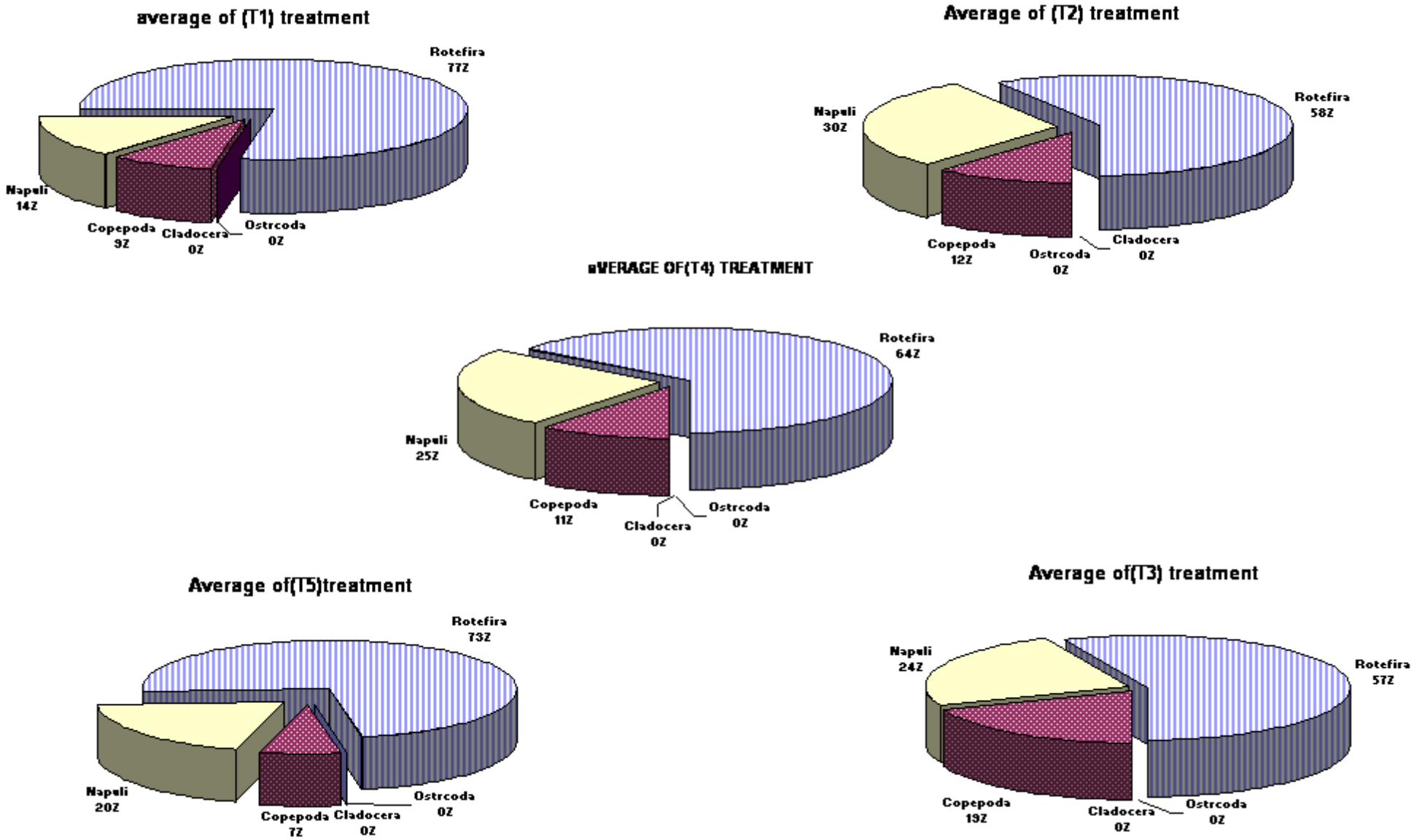


Fig (32b) zooplankton community (in percentage) in culture fish ponds with different treatments during the experimental period

Table (12) Average of total count of bacteria (T.C X 100) in mono-culture fish ponds with different treatments during the experimental period.

	T1	T2	T3	T4	T5
Jul	12.33 ^{d}±1.4	23.00 ^{c}±1.7	27.67 ^{cb}±1.2	32.33 ^{a}±1.2	29.50 ^{ab}±2.3
Aug	24.33 ^{c}±3.2	47.00 ^{a}±3.2	41.67 ^{ab}±1.7	38.00 ^{b}±3.2	28.33 ^{c}±1.4
Sep	24.00 ^{c}±2.6	43.67 ^{a}±2.6	44.00 ^{a}±0.6	34.00 ^{b}±2.3	29.00 ^{cb}±1.2
Oct	33.67 ^{c}±3.0	65.00 ^{a}±3.0	49.00 ^{b}±1.2	32.67 ^{c}±2.1	26.00 ^{d}±1.2
Average	23.58 ^{d} ± 2.4	44.66 ^{a} ± 4.6	40.58 ^{ab} ± 1.2	34.25 ^{cb} ± 2.4	28.21 ^{cd} ± 0.96

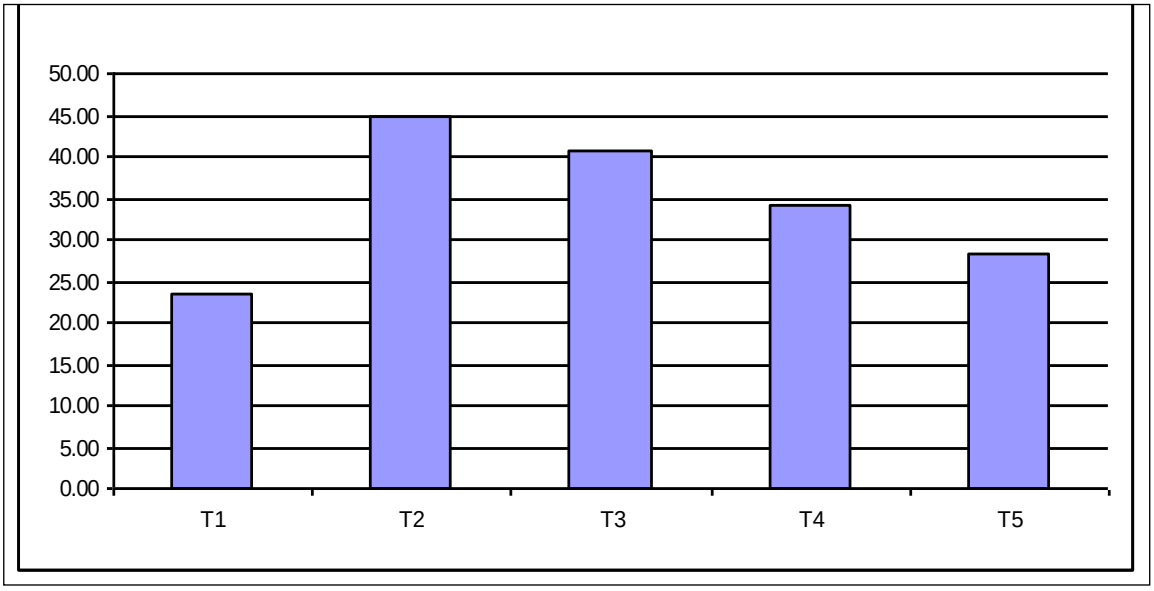


Fig (33) Average of total count of bacteria (T.C X 100) in mono-culture fish ponds with different treatments during the experimental period

Table (13) proximate analysis of the whole fish body of mono-culture fish ponds with different treatments at the end of the experiment.

	T1	T2	T3	T4	T5
DM %	76.37 ± 0.125	61.2 ± 0.06	66.255 ± 0.06	67.39 ± 0.03	72.14 ± 0.04
CP %	61.80±0.10	68.38±0.15	67.24±0.15	66.85±0.15	63.90±0.10
FAT %	32.84±0.06	27.74±0.07	28.37±0.11	28.72±0.09	30.86±0.03
ASH %	5.35±0.04	3.88±0.02	4.38±0.03	4.44±0.03	5.23±0.04

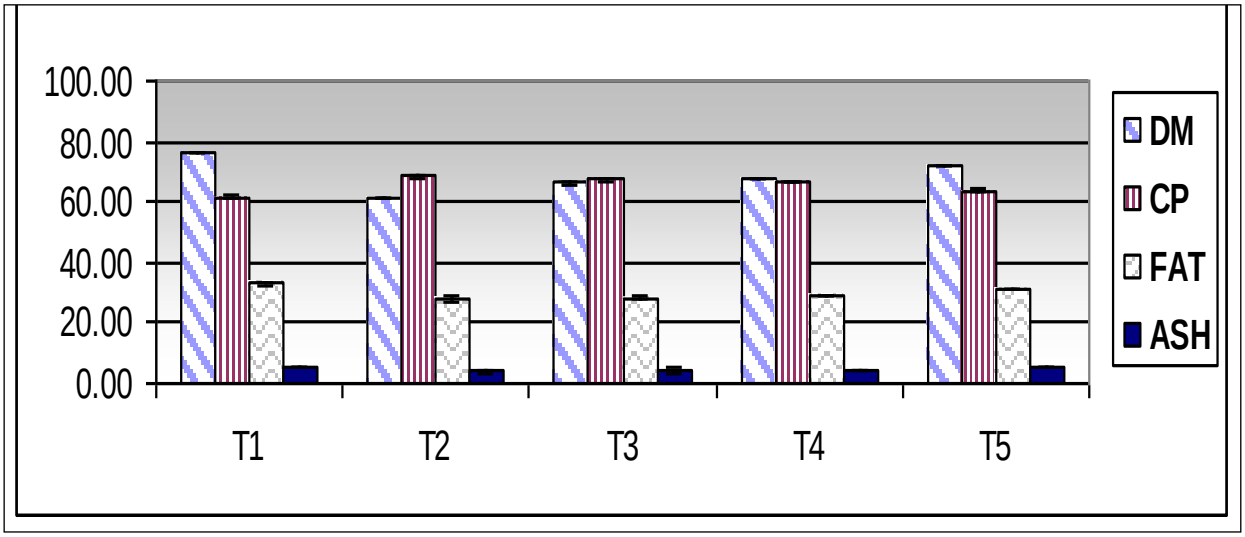


Fig (34) proximate analysis of the whole fish body of mono-culture fish ponds with different treatments at the end of the experiment.

Table (9) species composition of phytoplankton community in mono-culture fish ponds with different treatments during the experimental period (Org x 1000)																				
	Jul					Aug					Sep					Oct				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Cyanophyceae																				
Microcystis SP.	1,084,000	2,187,500	3,952,000	1,840,000	4,690,000	1,302,000	2,498,000	4,030,000	1,930,000	5,000,800	1,349,200	2,534,000	4,452,000	1,988,000	5,356,000	1,440,000	2,734,000	2,036,000	2,809,000	2,560,000
Anabaena SP.	852,000	0	0	0	0	792,000	0	0	0	0	1,100,000	0	0	0	0	960,400	0	0	0	0
Merismopedia SP.	1,950,000	2,688,000	3,308,000	5,300,000	0	2,130,800	3,748,000	3,530,000	5,880,000	0	2,492,000	4,134,000	3,788,000	6,128,000	0	2,530,000	4,002,000	3,712,000	5,660,000	0
Aphanocapsa SP.	668,000	660,000	956,000	0	0	912,000	790,000	992,000	0	0	1,264,000	832,000	1,032,000	0	0	1,196,000	634,000	1,032,000	0	0
chrococcum SP.	0	2,480,000	1,560,000	0	730,800	0	3,726,000	1,588,000	0	772,000	0	3,968,000	1,652,000	0	852,000	0	3,092,000	1,892,000	0	1,164,000
spirolina SP.	650,000	708,000	840,000	0	0	734,000	1,250,000	1,028,600	0	0	1,264,200	1,260,000	1,080,000	0	0	1,174,000	1,246,000	1,068,000	0	0
Cyano. subtotal	5,204,000	8,723,500	10,616,000	7,140,000	5,420,800	5,870,800	12,012,000	11,168,600	7,810,000	5,772,800	7,469,400	12,728,000	12,004,000	8,116,000	6,208,000	7,300,400	11,708,000	9,740,000	8,469,000	3,724,000
Chlorophyceae																				
Tetraedron SP.	312,000	312,500	360,000	1,721,000	1,960,000	1,720,000	314,000	384,000	1,744,000	1,970,000	2,540,000	319,000	430,000	1,885,000	1,988,000	2,120,000	1,692,000	2,530,000	1,980,800	1,940,000
Scenedesmus SP.	150,000	0	1,960,000	0	1,750,000	156,000	0	1,978,000	0	1,770,000	2,580,000	0	2,120,000	0	1,932,000	2,152,000	0	2,196,000	0	2,050,000
Chlorella SP.	2,060,000	2,812,500	5,134,000	4,996,000	3,794,000	2,080,000	13,500,000	6,040,000	5,396,000	4,480,000	7,500,000	11,492,000	6,500,000	5,694,000	4,912,000	4,514,000	3,356,000	2,496,000	5,520,200	3,692,000
Kirchnerilla SP.	1,640,000	900,000	840,000	0	980,000	1,704,000	978,000	952,000	0	1,024,000	2,492,000	990,000	960,000	0	1,040,000	2,106,000	986,000	1,284,000	0	1,064,000
Tetrastrum SP.	2,271,000	2,050,000	0	0	0	2,530,000	5,097,400	0	0	0	3,730,800	5,100,000	0	0	0	3,512,400	4,912,000	0	0	0
Errerella SP.	461,200	621,025	598,123	0	655,000	492,000	795,000	810,020	0	973,000	885,000	980,000	956,000	0	1,068,000	1,357,800	1,491,600	989,000	0	878,000
planktospheria SP.	1,160,000	2,518,000	1,250,000	0	2,060,000	1,810,000	2,518,800	1,271,640	0	3,260,000	2,052,000	2,684,400	1,013,400	0	4,500,000	2,074,000	2,546,000	1,097,400	0	4,274,000
Pandorina SP.	1,520,000	4,020,000	3,120,000	5,072,000	3,580,000	1,520,000	4,260,000	3,049,600	5,400,000	3,840,000	2,100,000	4,740,000	3,260,000	5,900,000	4,130,000	1,912,000	3,692,000	2,570,000	6,041,000	4,122,000
Clamydomonas SP.	900,000	1,340,000	1,160,000	1,840,000	1,680,000	1,030,000	1,364,000	1,196,000	1,820,000	1,708,400	1,312,000	1,500,000	1,840,000	2,120,000	2,480,000	1,292,000	1,466,000	1,826,000	1,996,000	2,372,000
Chloro. Subtotal	10,474,200	14,574,025	14,422,123	13,629,000	16,459,000	13,042,000	28,827,200	15,681,260	14,360,000	19,025,400	25,191,800	27,805,400	17,079,400	15,599,000	22,050,000	21,040,200	20,141,600	14,988,400	15,538,000	20,392,000
Bacillariophyceae																				
Synedra SP.	0	0	508,000	0	0	0	0	760,125	0	0	0	0	890,630	0	0	0	0	1,250,000	0	0
Nitzchia SP.	460,000	1,028,000	692,000	1,250,000	1,396,000	680,000	1,240,000	904,000	1,268,000	1,420,000	1,292,000	1,380,000	972,000	1,300,400	1,452,000	1,270,000	1,290,000	1,286,000	1,292,000	1,472,000
Navicula SP.	700,000	312,500	720,000	1,250,000	1,480,000	720,000	1,264,000	930,000	1,470,000	1,820,000	1,260,000	1,370,000	956,000	1,492,000	1,850,000	1,360,000	1,346,000	1,240,000	1,508,000	1,892,000
Melosira SP.	0	937,500	2,512,000	0	920,000	0	964,000	2,534,000	0	1,080,000	0	1,128,000	2,556,000	0	1,128,000	0	1,152,000	2,716,000	0	3,340,200
Cyclotella SP.	1,900,000	625,000	938,000	0	1,180,000	2,041,000	652,000	996,000	0	1,233,000	2,530,000	912,000	1,042,000	0	1,252,000	2,108,000	1,152,000	1,224,000	0	1,284,000
Tabellaria SP.	840,000	0	0	0	0	864,000	0	0	0	0	912,000	0	0	0	0	1,020,000	0	0	0	0
Bacill. Subtotal	3,900,000	2,903,000	5,370,000	2,500,000	4,976,000	4,305,000	4,120,000	6,124,125	2,738,000	5,553,000	5,994,000	4,790,000	6,416,630	2,792,400	5,682,000	5,758,000	4,940,000	7,716,000	2,800,000	7,988,200
Euglenophyceae (Phacus orbicularis)																				
Eugl. subtotal	0	309,200	334,000	2,498,000	2,290,000	0	1,268,000	1,222,000	2,690,000	2,120,000	0	1,290,000	1,258,400	2,840,000	2,300,000	0	1,168,000	1,270,400	1,780,000	2,040,000
Dinoflagellate (Predenium)																				
Dino. subtotal	698,000	912,000	0	0	1,020,000	934,000	1,229,600	0	0	1,108,000	940,000	1,308,400	0	0	1,180,000	1,040,000	1,280,000	0	0	1,152,000
Total count	20,276,200	27,421,725	30,742,123	25,767,000	30,165,800	24,151,800	47,456,800	34,195,985	27,598,000	33,579,200	39,595,200	47,921,800	36,758,430	29,347,400	37,420,000	35,138,600	39,237,600	33,714,800	28,587,000	35,296,200