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Full Length Research Paper

Ecomonitoring of Climate Impact on Earthen Pond Water Quality in El-Fayoum, Egypt

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Under field conditions, earthen ponds in AlFyoum province, Egypt (sizes, cultured species, use of aerators and fertilizers and disinfection program,) were investigated during summer, spring and autumn. Impact of seasonal alteration and ponds management on water physicochemical characters and microbial burden were investigated. Spring season characterized by significant differences between ponds in values of TS, TSS, TDS, EC., Alkalinity., pH , PO_4^-, TAN , Salinity ,COD, Hardness and Chlorides Vs autumn and summer. Autumn showed highest values of Total Coliform Count in 7/10 of ponds. Spring had highest total fungal count (TFC) in 6 /10 of ponds. The seasonal alteration didn't reveal significant differences in values of microbial load in all ponds except for Total Coliform Count which decreased significantly during spring Vs autumn. It's recommended to examine water periodically, public awareness to minimize recirculating water between ponds or at least increase rate of water exchange and use of aerators, as well as liming or alternative disinfectants between crops. Owners must be alert to the expected seasonal alteration on the water quality of earthen ponds aquaculture from the economic aspect.

Keywords: Earthen pond, water chemicals, seasons, management, microbial load

INTRODUCTION

Tilapias were considered suitable for culture, because of their high tolerance to adverse environmental conditions. The most common and widely practiced system of culture of tilapia is in earthen ponds and similar impoundments. Earthen pond aquaculture is the major type of aquaculture in Egypt where only waste lands are allowed to be used for fish mainly because of their high salt and alkali content and poor drainage. (ElGamal, 1997; Corpei, 2001; Altan et al., 2006; Matchand et al., 2009; Syobodova and Liod, 2009). Water quality in aquaculture fish ponds is controlled by a complex interplay of many factors. The amount of dissolved oxygen was controlled by respiration of fish and microorganisms, air-water-exchange and oxygen input in the water flowing into the pond. All biological and chemical processes in an aquaculture operation are influenced by temperature. The recorded maximum values of salinity in summer was attributed to the increase in the evaporation rate (Gullivar and Stefan, 1984; Huet and Timmermans, 1986; Buttner et al., 1993; Essa and Salama, 1994; Thomas and Michael, 1999) .Physical, chemical factors and biological contents of water in fish ecosystems were parameters influenced growth, reproduction and health of aquatic organisms, especially fish. Dissolved Oxygen concentration (DO) was considered the most important water quality variable in fish culture than other environmental variables because any factor that was outside the range tolerated by fish could cause stress or death (Gulliver and Stefan, 1984; Marchand et al., 2009). Most pathogens in aquaculture were opportunistic, causing disease only in fish with suppressed immune systems. Ammonia was toxic to fish if allowed to accumulate in production systems to toxic levels. If

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ammonia concentration gets high enough, the fish will became lethargic and eventually fallen into a coma and died. (Yanong, 2003; Hargreaves and Tucker, 2004). This field study was conducted to evaluate the impact of climate change on the earthen pond water quality (physicochemical characters and the microbial load) during summer, spring and autumn seasons in El-Fayoum district, Egypt.

MATERIAL AND METHODS

Sampling

Water samples were collected (Manually) from the ponds biweekly (two times monthly) between 12.00 and 14.00 h pm. Composite samples were obtained by collecting at many different sampling points and depths .Water temperature, dissolved oxygen, and pH were measured in situ. Water samples were placed in 1-L plastic bottles and transported to the laboratory for chemical analysis (Boyd and Tucker, 1992). Sterile bottles 250ml were used for collecting water samples for microbiological examination. Surface scum was avoided. Special weighted containers were required for sampling water from depths.The container was filled fully (for organic compound determinations) but space was left for aeration, mixing, etc. (for microbiological and inorganic analysis). All identified samples were transferred to the laboratory in ice box where they subjected to chemical and bacteriological examination.

Physical and Chemical Analysis of Water Samples

This analysis was done after (APHA, 1998). Temperature of water samples was measured at the time of sampling by means of an ordinary thermometer (range 0 – 100 °C). pH of water samples was determined by means of electrometric PH meter (pHep® HI 98107. Italy). Dissolved Oxygen (DO) was measured by (Membrane Electrode Method) through using portable waterproof dissolved oxygen meter (HI 9142. Italy) which was oxygen-sensitive polarographic membrane electrode with appropriate meter. The dissolved oxygen meter didn't be turned off between measurements to avoid depolarizing the probe. If the meter is not going to be used for about 1 hour, it was turned off. (Hargreaves and Tucker, 2002). Total hardness, Ethylene Damine Tetraacetic Acid (EDTA) Titrimetric Method. Total Solids and Total Dissolved Solids (TDS) measure were done after (APHA, 1998). TDS were measured by using waterproof EC/TDS/NaCl /°C Meter (HI 9835. Italy).Total Suspended Solids (TSS), the total suspended solids were obtained by calculation of the difference between total dissolved solids and total solids .TSS (g/L) = TS – TDS. Electrical Conductivity (EC) and Salinity (NaCl %), EC was measured by using waterproof EC/TDS/NaCl/°C Meter (HI 9835. Italy). NaCl Calibration, the HI 7037 calibration solution (sea water solution) was used as 100% NaCl standard. Chloride, was determined by using Argentometric method after (APHA, 1998).Total alkalinity was determined by Potentiometric titration to end-point pH. (APHA, 1998). Organic matter, Chemical oxygen demand (COD) was measured using the 'heat-of-dilution' dichromate oxidation method. (Boyd, 1990). Ammonia was determined by using (Direct Nesslerization Method), Nitrite (NO_2) was determined by using colorimetric method and Phosphates were determined by using the stannous chloride colorimetric method. (APHA, 1998).

Microbial examination

Heterotrophic plate count (The standard plate count)

Heterotrophic plate count was determined by Pour plate method after. Total fungal count of water, total fungal count was determined by using Pour Plate Technique according to (APHA, 1998) and Sabouraud Dextrose Agar. (Oxoid, Code: CM0041). Standard R- Total Coliform Fermentation Technique, total coliform count was determined by using multiple tube fermentation technique according to (APHA, 1998).

Statistical Analysis

Descriptive and analytical tests are carried out using Student "t" Test and Pearson 2-tailed correlation test is used (SPSS, 16).

RESULTS

DISCUSSION

Data collected via personnel questionnaires were directed to the farms owners and revealed that, surface area of studied ponds ranged from 5-50 acres. Number of rearing ponds (3-7) and number of hatcheries (2-5). Electricity was available in 4/5 of farms. Aerators was available and used in one farm only. The rate of water exchange is varied from twice/day to triple/week. Electricity in 60% of ponds used for water elevation to ponds and kerosene in 40% of ponds. Ponds disinfection program was applied via removal of upper surface layer alone or accompanied by liming or removal and dryness for 15 days between crops. Using of fertilizers was

Table 1. Seasonal Mean value ± SE of Temperature (C°).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	26.50 ± 0.86	26.75 ± 1.36	26.92 ± 1.43	26.92 ± 1.43	28.17 ± 1.20	28.17 ± 0.99	25.58 ± 1.20	27.42 ± 0.58	25.08 ± 1.39	25.92 ± 1.59	26.74 ± 0.38
Summer	28.08 ± 0.83	29.25 ± 0.69	30.42 ± 0.65	30.25 ± 1.20	30.42 ± 1.25	29.00 ± 0.72	28.50 ± 0.18	28.33 ± 0.73	27.50 ± 0.52	28.58 ± 0.71	29.03 ± 0.27
Autumn	20.25 ± 0.66	21.25 ± 0.66	22.75 ± 0.85	21.25 ± 0.66	21.50 ± 0.20	21.38 ± 0.24	21.50 ± 0.20	22.50 ± 0.20	21.50 ± 1.71	21.25 ± 1.39	21.51 ± 0.26

Table 2. Mean values ± SE of Dissolved oxygen (DO ppm).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	11.35 ± 2.25	9.98 ± 0.40	13.23 ± 0.81	13.44 ± 0.51	13.23 ± 0.28	11.63 ± 0.62	10.55 ± 0.67	9.28 ± 0.93	11.10 ± 0.68	11.55 ± 0.20	11.54 ± 0.32
Summer	9.93 ± 1.29	10.86 ± 1.07	13.58 ± 1.39	11.98 ± 1.19	11.93 ± 0.29	12.21 ± 0.36	12.31 ± 0.49	11.12 ± 0.45	11.62 ± 0.64	14.28 ± 0.44	11.98 ± 0.30
Autumn	9.55 ± 0.32	10.38 ± 0.09	12.50 ± 0.34	14.72 ± 0.92	13.34 ± 0.70	12.64 ± 0.13	13.86 ± 0.32	12.39 ± 0.38	10.51 ± 0.49	10.88 ± 0.58	12.08 ± 0.29

applied on farms A, C, D but not on farms B, E. The food used had 25% protein without additives in 60% of ponds but with poultry litter in 20% of ponds and with broken rice in 20% of ponds. The site direction of the ponds in farms A, C and E (ponds no.1, 2 and 5, 6 and 9, 10) were in the same wind direction which might enhance surface water proper aeration. Absence of Veterinary supervision and water quality analysis in all examined ponds .Farms B ,C and E (ponds no. 3,4 and 5,6 and 9,10) reared mixed species namely Tilapia Spp. and Mugil Spp. while farms A and C (ponds no. 1,2 ,9,10) reared only Tilapia.spp. Cultured Tilapia fry were obtained from external hatcheries (Alexandria and Kafr Al-Shaikh) as in farms A, D and E (ponds no. 1,2, 7,8, 9,10) but from inside farms hatcheries in farms B and C (ponds no. 3,4, 5,6).The combined use of both organic and inorganic fertilizers was a strategy for increased production of either fish food organisms or fry as recorded by (Adhkari, 2003).

The data in Table (1); indicated that the highest temperature mean was 29.03 ± 0.07C° in summer, in spring was 28.17 ± 1.20 C° and in summer was 30.42 ± 1.25 C° in pond no.5. In autumn was 22.75 ± 0.85 in pond no.3. It is noticed that pond no.5 had the maximum mean values of temperature during spring and summer .The obtained mean values were within the recommended values where the optimum temperature for warm water fish and namely *Tilapia spp.* is 28-30C° as reported by (Boyd, 1990; Lawson, 1995) .

Table (2); revealed that the maximum mean value of DO was 12.08 ± 0.29 mg/L in autumn. Pond no. 4. in autumn, had maximum value 14.72 ± 0.92 mg/L while in spring was 13.44 ± 0.51 mg/L . Pond no.10 had maximum value in summer (14.28 ± 0.44 mg/L). The solubility of oxygen decreases with increasing salinity; it is severely affected by temperature; electric conductivity where fresh water can hold 11.29 mg/L at 10 EC but at 30 EC mscm the value decreased to 7.56 mg/L. At 0 - 0.3 mg/L. Tilapia adults survive for short exposure at 0.3 - 0.75 mg/L was lethal to Tilapia if exposed to long. At 1 – 5 mg /L lead to impaired growth of Tilapia as reported by (Asmal, 1996). Warm water fish more tolerant to low DO than cold water species, > 5.0 mg/L was recommended, > 1.5 mg/L lived for several days, > 1.0 mg/L lived for several hours, and < 0.3 mg/L was the lethal concentration as recorded by (Lawson, 1995).

Table (3); the maximum mean value of Chloride was 3291.69 ± 329.50 mg/L in autumn. Pond no.6. had

Table 3. Seasonal Mean values ± SE of Chloride (mg/ L).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	2628 ± 76.64	2704.17 ± 76.22	2858.33 ± 132.77	3348.33 ± 124.64	1483.33 ± 194.04	2469.67 ± 28.96	1447.50 ± 47.99	1383.33 ± 130.31	1505.50 ± 29.14	1552.17 ± 36.41	2138.03 ± 95.64
Summer	2281.83 ± 58.41	2187.50 ± 76.02	3555.83 ± 98.96	4166.00 ± 67.44	5112.50 ± 669.38	5198.00 ± 589.47	1651.67 ± 61.73	1602.50 ± 55.13	1487.50 ± 74.65	1479.17 ± 41.54	2872.25 ± 203.83
Autumn	2439.75 ± 60.87	2205.00 ± 85.39	3817.00 ± 6.44	4240.00 ± 34.16	6960.75 ± 14.91	6967.50 ± 25.62	1983.75 ± 12.81	1703.13 ± 96.07	1256.25 ± 106.74	1343.75 ± 64.04	3291.69 ± 329.50

Table 4. Seasonal mean values ± SE of Hardness (mg/ L).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	1480.00 ± 20.94	1540.00 ± 23.63	1901.67 ± 41.37	1950.00 ± 44.63	1034.17 ± 224.95	1545.83 ± 167.82	925.83 ± 11.21	855.83 ± 81.07	1030.83 ± 39.67	1179.17 ± 71.04	1344.33 ± 56.66
Summer	1398.33 ± 31.67	1390.00 ± 43.20	1948.33 ± 28.33	2235.00 ± 17.61	2831.67 ± 325.69	3238.33 ± 58.83	1015.00 ± 19.92	999.17 ± 24.85	1106.67 ± 74.19	1035.83 ± 34.07	1719.83 ± 105.27
Autumn	1404.50 ± 36.25	1453.25 ± 27.79	2073.25 ± 27.79	2157.00 ± 61.87	3833.75 ± 12.81	3774.38 ± 66.18	1138.75 ± 29.89	1031.88 ± 57.64	935.63 ± 104.60	951.56 ± 65.11	1875.39 ± 168.27

highest chlorides 6967.50 ± 25.62 mg/L in autumn. In spring was 3348.33 ± 124.64 mg/L in pond no.4. In summer was 5198.00 ± 589.47 mg/L in pond no.6 .Summer and autumn had high mean values of Chloride in pond no.6.Chloride is contributed to the concentration of (TDS) and salinity of water. At high concentrations it had little effect on fish health or behavior .At high concentrations near the coast, some freshwater fish may show symptoms similar to those given for salinity as reported by (Asmal, 1996).

Table (4); revealed the maximum mean value of Hardness was 1875.39 ± 168.27 mg/L in autumn. The maximum mean value in autumn was 3833.75 ± 12.81 mg/L in pond no.5. In spring was 1950.00 ± 44.63 mg/L in pond no.4 In summer was 3238.33 ± 58.83 mg/L in pond no.6 .The current data indicated increased Hardness value in hot period and the decreased value in autumn were exceeded that reported by (Abdo, 2005). However, Hardness affects aquaculture species and operations through its chemical interactions with other species in water. Hardness levels for aquaculture, as $CaCO_3$/L are classified as, Soft at 0–75 mg/L, moderate at 75–150 mg/L ,hard 1 at 50–300 mg/L and very hard > 300 mg/L as recorded by (Zweig et al., 1999).

Table (5); indicated that the maximum value of pH was 8.39 ± 0.04 in autumn as sum of all ponds .In autumn was 8.80 ± 0.00 in pond no. 7. In spring was 8.10 ± 0.08 in pond no.4. In summer was 8.32 ± 0.10 in pond no.8. Optimum pH for warm water fish was 6.5–9.0 as desirable range for fish production, 9.0–11.0 slow growth and > 11.0 alkaline death point as reported by (Zelay et al., 2001) . The increased pH values during summer and autumn were coincided with the results of (Abdo, 2005) where he recorded pH during hot period ranged from 8.02-8.46 in Abu-Za`able pond. In addition to the influence of pH and temperature when they increased, the amount of TAN in the toxic NH3 increased as reported by (Buttner et al., 1993).

Table (6); the maximum value of NO2 was 0.10 ± 0.03 mg/L-N in autumn Vs other seasons. In autumn was 0.64 ± 0.05 mg/L-N in pond no.3. In spring was 0.49 ± 0.05 mg/L-N in pond no. 3. In summer maximum value was 0.08 ± 0.00 mg/L-N in pond no.4. On regard to Pond no.3; it had highest NO2 mean during spring and autumn.

Table 5. Seasonal Mean values ± SE of pH.

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	7.61 ± 0.01	7.69 ± 0.03	8.04 ± 0.07	8.10 ± 0.08	7.57 ± 0.18	7.99 ± 0.04	8.17 ± 0.03	7.54 ± 0.68	7.50 ± 0.03	7.66 ± 0.06	7.79 ± 0.07
Summer	8.02 ± 0.07	7.88 ± 0.09	8.23 ± 0.14	8.24 ± 0.15	8.06 ± 0.11	8.01 ± 0.12	8.30 ± 0.12	8.32 ± 0.10	7.93 ± 0.10	8.03 ± 0.04	8.10 ± 0.04
Autumn	8.25 ± 0.02	7.92 ± 0.11	8.36 ± 0.02	8.50 ± 0.00	8.25 ± 0.02	8.46 ± 0.02	8.80 ± 0.00	8.67 ± 0.06	8.35 ± 0.02	8.36 ± 0.02	8.39 ± 0.04

Table 6. Seasonal mean values ± SE of NO_2 (mg/L N).

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	0.03 ± 0.00	0.03 ± 0.01	0.49 ± 0.05	0.07 ± 0.00	0.06 ± 0.01	0.05 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.01	0.02 ± 0.00	0.08 ± 0.02
Summer	0.05 ± 0.01	0.03 ± 0.00	0.20 ± 0.04	0.08 ± 0.00	0.06 ± 0.01	0.05 ± 0.01	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.03 ± 0.01	0.06 ± 0.01
Autumn	0.02 ± 0.00	0.02 ± 0.00	0.64 ± 0.05	0.09 ± 0.00	0.06 ± 0.00	0.07 ± 0.01	0.03 ± 0.01	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.10 ± 0.03

Table 7. Seasonal mean ± SE of Total Ammonia Nitrogen values (mg/L N).

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	0.56 ± 0.05	0.85 ± 0.05	0.94 ± 0.03	0.96 ± 0.03	0.52 ± 0.07	0.60 ± 0.06	0.05 ± 0.00	0.05 ± 0.01	0.05 ± 0.01	0.04 ± 0.01	0.46 ± 0.05
Summer	1.18 ± 0.03	1.71 ± 0.14	0.76 ± 0.03	1.10 ± 0.04	0.50 ± 0.04	0.63 ± 0.06	0.08 ± 0.00	0.05 ± 0.01	0.04 ± 0.00	0.06 ± 0.01	0.61 ± 0.07
Autumn	1.40 ± 0.03	1.58 ± 0.35	1.88 ± 0.35	1.58 ± 0.11	0.43 ± 0.01	0.80 ± 0.07	0.08 ± 0.01	0.09 ± 0.00	0.07 ± 0.00	0.07 ± 0.00	0.80 ± 0.12

These recorded levels and the probable reduced growth when persisted and associated with high chloride level, increased susceptibility to disease, were within the levels reported by (Wester, 1991; Buttner et al., 1993; Lawson, 1995). NO2 concentrations should be interpreted in conjunction with Salinity, Alkalinity, pH, DO and temperature measurement as revealed by (Asmal, 1996; Zweig et al., 1999), while NO2 in freshwater levels above 1.0 ppm would be harmful to the fish and at persistently high levels (over 50 ppm) was stressful to some species. Elevated levels in an aquarium might lead to excess algal growth as stated by (Lewbert and harms, 2008).This pond had highest temperature and TAN mean values during autumn, while it had highest NO2 during autumn and spring, TFC mean values in spring. These results indicated increased pond organic contents.

Table 7; the maximum value of total ammonia nitrogen (TAN) was 0.80 ± 0.12 mg/L-N in autumn Vs other seasons. In spring was 0.96 ± 0.03 mg/L-N in pond no.4. In summer was 1.71 ± 0.14 mg/L-N in pond no .2. In

Table 8. Seasonal mean ± SE of Phosphate values (mg/L PO_4).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	9.92 ± 0.80	13.05 ± 1.41	22.73 ± 0.67	20.58 ± 0.66	27.67 ± 1.38	21.79 ± 2.04	21.31 ± 0.40	18.49 ± 1.13	15.65 ± 0.91	17.88 ± 0.49	18.91 ± 0.71
Summer	14.51 ± 0.83	14.97 ± 0.56	18.50 ± 0.48	22.27 ± 0.69	25.48 ± 2.15	24.26 ± 2.71	21.42 ± 0.68	19.10 ± 0.98	15.62 ± 0.38	20.83 ± 1.11	19.69 ± 0.60
Autumn	11.88 ± 1.28	13.30 ± 0.34	24.51 ± 0.76	24.34 ± 0.13	28.51 ± 0.19	29.89 ± 0.73	20.44 ± 1.92	24.08 ± 0.26	17.48 ± 0.21	19.17 ± 0.41	21.36 ± 0.94

Table 9. Seasonal mean ± SE of Alkalinity values (mg/L).

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	253.50 ± 9.11	315.17 ± 17.16	414.00 ± 51.76	427.17 ± 45.34	141.67 ± 29.24	194.58 ± 22.31	402.42 ± 4.81	364.83 ± 34.35	327.00 ± 11.22	310.33 ± 18.58	315.07 ± 14.36
Summer	368.67 ± 42.77	349.67 ± 42.51	320.67 ± 28.69	372.83 ± 26.89	417.50 ± 61.36	409.33 ± 4.61	354.67 ± 15.70	419.17 ± 24.90	318.33 ± 20.40	316.17 ± 18.60	364.70 ± 10.70
Autumn	589.00 ± 53.58	632.75 ± 40.77	461.25 ± 67.85	443.25 ± 70.87	667.50 ± 76.85	467.00 ± 10.25	672.19 ± 16.01	675.13 ± 20.92	437.31 ± 31.38	390.06 ± 49.31	543.54 ± 22.05

autumn was 1.88 ± 0.35 mg/L-N in pond no.3. This TAN value was more than the results recorded by (Lawson, 1995) ,where optimum TAN was at < 0.05 and at < 1.0 mg l^{-1} TAN were safe concentrations. High TAN and low DO concentration during the summer and spring were the major factors responsible for mortality in sewage-fed fishponds according to (WHO, 1989).The maximum values in spring and summer were within the toxic levels of TAN according to results of (Zweig et al., 1999), where they stated that, toxic effects of NH3 were felt at concentrations between 0.6 and 2.0 ppm and confirmed the influence of some physical characters on TAN toxicity as temperature, pH and low DO which control ratio of toxic NH_3 to NH_4^+ and increase TAN toxicity .In addition to (Lewbert and Harms, 2008) who stated that a TAN measurement of 3.0 ppm would be deadly at a pH of 8.5 in freshwater but relatively harmless at a pH of 6.0 for a few days . To assess the potential toxicity of these concentrations it is important to know the amount of non-dissociated ammonia (NH_3) present. This was calculated from the measured values for total ammonia (NH_4^++NH_3), temperature (T, °C) and water pH, using the formula:

$$NH_3 = \frac{NH_4^+ + NH_3}{10^{(10.07-0.033T-pH)}+1}$$

(Syobodova and Liod, 2009).

Table (8); revealed that the maximum value of PO_4^- was 21.36 ± 0.94 mg/L PO_4^- in autumn Vs other seasons. In spring was 27.67±1.38 mg/L PO_4^- in pond no.5. In summer was 25.48 ± 2.15 mg/L PO_4 in pond no.5. In autumn was 29.89 ± 0.73 mg/L PO_4 in pond no. 6. Elevated phosphate levels could be found where large quantities of organic matter were decomposing after their use as fertilizers in agriculture and runoff from these areas. Typical phosphate was 300µg/L or more in nutrient- enriched waters. Phosphate concentrations should be interpreted in conjunction with the concentrations of Nitrate, TSS and DO Site-specific conditions should also be taken into account as mentioned by (Asmal, 1996). Pond no.1 had minimum PO4+ mean value and its management condition might enhance minimizing organic load with absence of fertilizers as well; the site direction which allowed natural surface water mixing with air temperature and O_2 despite of no aerator was available.

The data in Table (9); the maximum value of Alkalinity was 543.54 ± 22.05 mg/L in autumn .The highest value in spring was 427.17 ± 45.34 mg/L in pond no.4.The maximum value in summer was 419.17 ± 24.90 mg/L in pond no.8.The highest value in autumn was 675.13 ± 20.92 mg/L in pond no.8. All the maximum mean values in all seasons were higher than that reported by many

Table 10. Seasonal mean ± SE of electric conductivity (E.C) values (ms/cm).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	6.89 ± 0.08	6.69 ± 0.11	10.55 ± 0.12	11.17 ± 0.10	7.46 ± 0.24	9.12 ± 0.11	5.08 ± 0.07	4.80 ± 0.44	4.77 ± 0.08	5.22 ± 0.13	7.18 ± 0.30
Summer	6.77 ± 0.17	6.89 ± 0.05	10.57 ± 0.31	12.08 ± 0.42	14.44 ± 1.59	14.90 ± 1.19	5.81 ± 0.23	5.44 ± 0.20	4.72 ± 0.17	5.04 ± 0.11	8.66 ± 0.53
Autumn	6.82 ± 0.01	7.06 ± 0.05	11.43 ± 0.15	12.57 ± 0.02	18.64 ± 0.07	18.75 ± 0.24	6.38 ± 0.16	5.41 ± 0.47	3.60 ± 0.30	4.81 ± 0.34	9.55 ± 0.85

Table 11. Seasonal mean ± SE of Total solids (TS) (g/L).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	5.8 ± 0.07	5.92 ± 0.1	10.8 ± 0.12	11.28 ± 0.1	7.9 ± 0.25	8.98 ± 0.11	3.37 ± 0.04	3.14 ± 0.29	3.67 ± 0.06	4.02 ± 0.1	6.49 ± 0.38
Summer	5.7 ± 0.15	6.08 ± 0.03	10.86 ± 0.32	12.21 ± 0.42	15.19 ± 1.69	14.7 ± 1.17	3.85 ± 0.15	3.56 ± 0.13	3.67 ± 0.14	3.88 ± 0.09	7.97 ± 0.62
Autumn	5.76 ± 0.01	6.25 ± 0.04	11.71 ± 0.16	12.69 ± 0.02	19.76 ± 0.07	18.47 ± 0.23	4.24 ± 0.11	3.54 ± 0.31	2.77 ± 0.23	3.7 ± 0.26	8.89 ± 0.97

authors, where Alkalinity in excess of 300 ppm didn't adversely affect fish but interfered with action of commonly used disinfectants (namely copper sulphate) as recorded by (Buttner et al., 1993), and 20 – 400 mg/L Alkalinity was sufficient for most aquaculture purposes and 100 or 150 mg/L was desirable as recorded by (Zweig et al., 1999).

The data in Table (10); the maximum mean value of Electric Conductivity (EC) was 9.55 ± 0.85 ms/cm in autumn Vs other seasons. In spring was 11.17 ± 0.10 ms/cm in pond no.4. In summer was 14.90 ± 1.19 ms/cm in pond no.6. In autumn was 18.75 ± 0.24 ms/cm in pond no. 6 .This pond had maximum EC values during summer and autumn .This pond also had maximum mean values of TDS, NaCl % and Chlorides during summer, while pond no.4 had maximum value during spring. The increased values of TDS and EC in hot period were coincided with that recorded by (Abdo, 2005).

The data in Table (11); the maximum mean value of Total Solids (TS) was 8.89 ± 0.97 g. /L in autumn Vs other seasons. In spring was 11.28 ± 0.1 g. /L in pond no.4.The maximum value in summer was 15.19 ± 1.69 g. /L in pond no.5. The highest value in autumn was 19.76 ± 0.07 g. /L in pond no. 5. Pond no. 9 had minimum EC and TS. It had its fry from external hatcheries, reared *Tilapia niloticus* only (Mono-culture) and its width was in same wind direction. It had no fertilizers but had aerator.

The data in Table (12); the maximum value of Total Suspended Solids (TSS) was 4.11 ± 0.55 g. /L in autumn Vs other seasons. In spring was 5.53 ± 0.06 g. /L in pond no.3. In summer was 8.03 ± 0.89 g. /L in pond no. 5. In autumn was 10.44 ± 0.04 g. /L in pond no.5. The recorded values in all seasons were detrimental to fish in comparison with the recoded values by (Boyd, 1990), where he stated that TSS concentration had no harmful effects on fisheries at 25 mg l^{-1}, acceptable range was 25–80 mg l^{-1} and the detrimental value to fisheries was 80 mg l^{-1}.

The data in Table (13); the maximum mean value of Total Dissolved Solids (TDS) was 4.77 ± 0.42 g. /L in autumn. The maximum mean value in spring was 5.59 ± 0.05 g. /L in pond no.4. The highest value in summer was 7.46 ± 0.59 g. /L in pond no.6. The maximum value in autumn was 9.38 ± 0.12 g. /L in pond no.6.

The data in Table (14); the maximum mean value of Salinity (NaCl %) was 18.24 ±1.65 % in autumn Vs other seasons. In spring was 21.80 ± 0.19 % in pond no.4. In summer was 28.86 ± 2.37 % in pond no.6. In autumn was

Table 12. Seasonal mean ± SE of Total suspended solids (TSS) (g/L).

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	2.35 ± 0.03	2.58 ± 0.04	5.53 ± 0.06	5.7 ± 0.05	4.18 ± 0.13	4.42 ± 0.05	0.83 ± 0.01	0.74 ± 0.07	1.29 ± 0.02	1.41 ± 0.03	2.9 ± 0.24
Summer	2.31 ± 0.06	2.65 ± 0.02	5.57 ± 0.16	6.17 ± 0.21	8.03 ± 0.89	7.24 ± 0.57	0.95 ± 0.04	0.84 ± 0.03	1.29 ± 0.05	1.36 ± 0.03	3.64 ± 0.36
Autumn	2.33 ± 0.01	2.72 ± 0.02	6 ± 0.08	6.41 ± 0.01	10.44 ± 0.04	9.09 ± 0.11	1.05 ± 0.03	0.84 ± 0.07	0.97 ± 0.08	1.3 ± 0.09	4.11 ± 0.55

Table 13. Seasonal mean ± SE of Total dissolved solids (TDS) (g/L).

Pond season	8	1	2	3	4	5	6	7	9	10	Total
Spring	2.40 ± 0.22	3.45 ± 0.04	3.34 ± 0.06	5.27 ± 0.06	5.59 ± 0.05	3.73 ± 0.12	4.56 ± 0.05	2.54 ± 0.03	2.39 ± 0.04	2.61 ± 0.07	3.59 ± 0.15
Summer	2.72 ± 0.10	3.39 ± 0.09	3.43 ± 0.02	5.29 ± 0.16	6.04 ± 0.21	7.16 ± 0.80	7.46 ± 0.59	2.90 ± 0.12	2.38 ± 0.09	2.52 ± 0.06	4.33 ± 0.26
Autumn	2.70 ± 0.23	3.43 ± 0.01	3.53 ± 0.02	5.71 ± 0.08	6.28 ± 0.01	9.32 ± 0.03	9.38 ± 0.12	3.19 ± 0.08	1.80 ± 0.15	2.40 ± 0.17	4.77 ± 0.42

Table 14. Seasonal Mean ± SE of NaCL %

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	13.17 ± 0.19	12.95 ± 0.16	20.58 ± 0.24	21.80 ± 0.19	14.18 ± 0.45	17.33 ± 0.20	9.41 ± 0.12	8.89 ± 0.81	7.46 ± 0.08	9.76 ± 0.22	13.55 ± 0.62
Summer	12.87 ± 0.42	12.65 ± 0.06	20.56 ± 0.60	23.41 ± 0.81	27.63 ± 3.12	28.86 ± 2.37	10.76 ± 0.43	10.07 ± 0.36	8.27 ± 0.30	9.39 ± 0.18	16.45 ± 1.05
Autumn	13.13 ± 0.06	13.01 ± 0.04	22.29 ± 0.30	24.51 ± 0.04	35.79 ± 0.04	35.97 ± 0.29	11.83 ± 0.28	10.01 ± 0.88	6.71 ± 0.53	9.19 ± 0.49	18.24 ± 1.65

35.97 ± 0.29 % in pond no.6 .The increased salinity decreased the solubility of oxygen, for every 9000 mg/L increased in salinity the DO solubility decreased by 5 % as demonstrated by (5), as well, Nile Tilapia perform better at salinities below 5 ppt and tilapia prefer salinity <0.5-1.0 ppt as recorded by (Thomas and Michael, 1999), while the optimum salinity for *Tilapia aurea* and *Tilapia nilotica* was 0–10‰ (0.1-1%) after (Zweig et al., 1999). As well as the salinity not only affects osmoregulation but also it influences the concentration of un-ionized ammonia (Plumb, 2002).

The data in Table (15); indicated that the maximum mean value of Chemical Oxygen Demand (COD) was 73.72 ± 1.91 mg O_2/L in autumn. The highest value in spring was 77.04 ± 7.55 mg O_2/L in pond no. 9. In summer was 75.11± 2.60 mg O_2/L in pond no. 7. In autumn was 97.86 ± 4.23 mg O_2/L in pond no.9. Maximum COD value was 80.9 mg O_2/L in pond no.9 and minimum was 56.3 mg O_2/L in pond no.3. Pond no.9 had the highest COD values during spring and autumn. The

Table 15. Seasonal mean ± SE of chemical oxygen demand (COD) values (mg O_2/L) .

Pond season	1	2	3	4	5	6	7	8	9	10	Total
Spring	63.97 ± 1.64	64.77 ± 4.47	61.48 ± 1.97	60.75 ± 2.95	68.33 ± 3.51	52.57 ± 5.15	74.82 ± 0.83	62.63 ± 6.00	77.04 ± 7.55	65.38 ± 1.63	65.17 ± 1.48
Summer	70.70 ± 1.16	66.05 ± 0.71	46.90 ± 3.20	59.75 ± 2.09	64.52 ± 5.02	56.48 ± 7.40	75.11 ± 2.60	71.01 ± 2.98	73.52 ± 3.59	71.23 ± 2.35	65.53 ± 1.52
Autumn	75.33 ± 1.39	66.88 ± 3.48	62.73 ± 2.48	66.40 ± 3.56	67.28 ± 3.14	63.35 ± 4.61	83.11 ± 0.98	83.19 ± 0.30	97.86 ± 4.23	71.04 ± 3.05	73.72 ± 1.91

Table 16. Seasonal [(mean values± SE) x 10^2] of Total Coliform count (T. Coli. C) (CFU/ml water).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	7.88 ± 2.23	8.52 ± 2.96	16.33 ± 0.33	17.00 ± 0.45	2.60 ± 0.64	4.07 ± 1.16	3.35 ± 0.56	2.82 ± 1.29	8.13 ± 2.24	8.12 ± 1.83	7.88 ± 0.80
Summer	12.60 ± 1.52	4.12 ± 1.04	10.58 ± 2.95	11.62 ± 3.04	6.97 ± 2.25	9.27 ± 2.60	7.65 ± 2.11	5.87 ± 2.34	12.53 ± 2.62	14.10 ± 2.23	9.53 ± 0.79
Autumn	14.30 ± 1.70	14.30 ± 1.70	11.40 ± 2.20	16.50 ± 0.50	2.15 ± 0.12	9.95 ± 2.21	12.60 ± 1.96	6.35 ± 0.95	16.50 ± 0.50	11.65 ± 2.63	11.57 ± 0.83

degradation of organic matter and the solubility of oxygen were all influenced by temperature, the type of fish, life stage, level of activity and dissolved oxygen concentration also influence the respiration rate (Zweig et al., 1999).

The data in Table (16); autumn had high values Total Coliform Count in 7/10 of ponds, where the highest mean value was (16.50 ± 0.50) x 10^2 CFU/100 ml in pond no.9. On regard to the higher value in spring was (17.00 ± 0.45) x 10^2 CFU/100 ml and (16.33 ± 0.33) x 10^2 CFU/100 ml in ponds no.4 and 3 respectively, while during summer the highest value was (12.60 ± 1.52) x10^2 CFU/100 ml in pond no.1. The obtained data were so high than that recommended by (WHO, 1989) where they indicated that, in wastewater fed ponds, concentrations of 10^4 CFU /100 ml were acceptable for culture of both fish and aquatic macrophytes. They assumed that a reduction of one order of magnitude taken place in-pond, so that in-pond concentrations should be less than 10^3 per 100 ml. At concentrations above 10^4 and 10^5 per 100 ml, the potential for fecal coliform and other pathogens to invade muscle tissue was very high. In addition to, reliance on coliform standards might overestimate potential health risks, unduly burdening developing countries in their efforts to develop shellfish resources in tropical waters as recorded by (Rice, 1992).

The data in Table (17); the highest mean values of TCC were noticed in 5/10 of ponds during autumn with maximum value (6150 ± 1537.04) x10^2 CFU/ml in pond no.5 followed by 4/10 of ponds during spring with highest value (11450 ± 3058.73) x10^2 CFU/ml in pond no.4, while during summer the highest value was (6621.67 ± 4404.78) x10^2 CFU/ml in pond no.4. Some researchers recommend that the concentration of total bacteria (standard plate count per ml) be used to assess the risk of microbial contamination .They pointed out that if total bacteria reached 1.0 to 5.0 multiplied by 10^4 / ml, then bacteria were likely to appear in muscle tissue (Burns et al., 1982).

The data in Table (18); the highest TFC was recorded in 6/10 of ponds during spring with maximum value (89.63 ± 40.17) x10^2 CFU/ml in pond no. 10, followed by summer figures with maximum value (73.50 ± 19.18) x10^2 CFU/ml in pond no.2, while during autumn the highest value was (62.75 ± 12.81) x10^2 CFU/ml in pond no.2 . The previously mentioned data confirmed the seasonal impact on the microbial load where autumn characterized by the maximum mean values of T. Coliform. C and TCC which might be attributed to the availability of organic contents manifested via maximum ammonia, nitrites,

Table 17. Seasonal [(mean values± SE) x 10^2] of Total colony count (TCC) (CFU/ml water).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	819.33 ± 174.62	165.17 ± 31.92	1085 ± 214.41	11450 ± 3058.73	880 ± 178.23	247.33 ± 121.33	529.75 ± 231.81	338.67 ± 129.68	93.33 ± 49.53	1948.33 ± 422.85	1755.69 ± 513.95
Summer	561.67 ± 59.74	202.67 ± 42.81	516.33 ± 187.23	6621.67 ± 4404.78	520 ± 189.67	1006.67 ± 143.94	373.67 ± 168.35	222.50 ± 91.09	287.17 ± 87.11	791.67 ± 183.13	1110.40 ± 473.37
Autumn	542.50 ± 25.62	237.50 ± 8.54	1032.50 ± 78.89	872.50 ± 219.67	645 ± 173.23	637.50 ± 253.52	6150 ± 1537.04	480 ± 136.63	302.50 ± 93.93	2150 ± 210.16	1305 ± 305.87

Table 18. Seasonal [(mean values± SE) x 10^2] of Total fungal count (TFC) (CFU/ml water).

Pond Season	1	2	3	4	5	6	7	8	9	10	Total
Spring	16.05 ± 3.74	47.89 ± 13.65	53.13 ± 14.35	13.20 ± 3.94	14.12 ± 2.78	11.21 ± 3.44	6.83 ± 1.13	26.60 ± 4.22	20.77 ± 10.93	89.63 ± 40.17	29.94 ± 5.38
Summer	20.33 ± 2.17	73.50. ± 19.18	43.08 ± 28.96	12.22 ± 8.13	12.13 ± 2.72	26.83 ± 4.35	23.12 ± 12.16	9.50 ± 4.12	7.70 ± 2.42	4.05 ± 1.70	23.25 ± 4.39
Autumn	19.75 ± 0.85	62.75 ± 12.81	2.40 ± 0.20	1.59 ± 0.39	10.48 ± 2.81	20.83 ± 7.63	37.76 ± 8.90	7.20 ± 2.36	15.75 ± 0.25	15.00 ± 1.47	19.35 ± 3.22

phosphate values and the consequent increased DO and COD values utilized by the microbial and fish biochemical activities. On regard to ponds, Pond no .5 had the highest mean values of Total Coliform and TCC during summer and spring respectively It had maximum values of PO4+ during spring and summer, TS, TSS during autumn .Pond no.2 had maximum TFC and lowest TCC. Its site was in same wind direction, reared *Tilapia niloticus* only and obtained the fry from external hatcheries. It also had no fertilizers used.

Table (19): highly significant decrease ($P \leq 0.001$) in temperature values was between spring Vs summer and also between autumn Vs spring and summer. No significant differences were noticed in DO values between seasons. Chloride was significantly decreased ($P= 0.01$) in spring Vs summer and highly significant decreased ($P \leq 0.001$) Vs autumn. Hardness was significantly decreased ($P \leq 0.01$) in spring Vs summer while highly significant decreased ($P \leq 0.001$) was recorded Vs autumn .The data of pH values demonstrated highly significant decrease ($P \leq 0.001$) between spring Vs summer and autumn ,and also between summer Vs autumn. Alkalinity decreased significantly ($P = 0.01$) during spring Vs summer while highly significant increase ($P \leq 0.001$) was recorded between autumn Vs spring and summer. No significant difference was noticed in Nitrite mean values between seasons. Highly significant decrease ($P \leq 0.001$) in TAN values was recorded between spring Vs autumn. PO4+ concentration was less significantly decreased ($P = 0.03$) during spring in comparison to autumn. EC was less significantly decreased during spring Vs summer ($P = 0.04$) while highly significant decrease ($P \leq 0.001$) was recorded Vs autumn. TS were significantly decreased during spring Vs autumn ($P = 0.01$). TSS were less significantly decreased ($P = 0.03$) during spring Vs autumn. TDS were less significantly decreased during spring Vs summer ($P = 0.04$) while highly significant decrease ($P \leq 0.001$) was recorded between spring Vs Autumn. NaCl % was less significantly decreased during spring Vs summer ($P = 0.04$) while highly significant decrease was recorded during spring Vs autumn ($P \leq 0.001$). Highly significant increase in mean values of COD ($P \leq 0.001$) was recorded between autumn Vs spring and summer. From the above mentioned data it's clear that the spring season characterized by the significant differences in the mean values of TS, TSS, TDS, EC., Alk., PH , PO_4^-, TAN ,Salinity ,COD, Hd and Chlorides Vs autumn and summer .The absence of significant differences of mean DO values between

Table 19. Seasonal differences in physicochemical characters .

Seasons	Spring		Summer		Autumn	
Parameters	Summer	Autumn	Spring	Autumn	Spring	Summer
Temperature	-2.49*	5.23*	2.49*	7.72*	-5.22*	-7.72*
C°	0.00	0.00	0.00	0.00	0.00	0.00
D.O.	-0.46	-0.54	0.46	-0.08	0.54	0.08
Ppm	0.27	0.25	0.27	0.86	0.24	0.86
Chloride	-734.25*	-1153.66*	734.2*	-419.41	1153.6*	419.41
mg/L	0.01	0.00	0.01	0.17	0.00	0.17
Hardness	-375.50*	-531.01*	375.5*	-155.51	531.01*	155.51
mg/L	0.01	0.00	0.01	0.32	0.00	0.33
PH	-.31*	-.60*	.31*	-.29*	.60*	.29*
	0.00	0.00	0.00	0.00	0.00	0.00
Alkalinity	-49.68*	-228.46*	49.68*	-178.78*	228.46*	178.78*
mg/L	0.01	0.00	0.01	0.00	0.00	0.00
NO_2-N	0.02	-0.02	-0.02	-0.04	0.02	0.04
mg/L	0.37	0.46	0.37	0.12	0.46	0.12
NH_3-N	-0.15	-.34*	0.15	-0.19	.34*	0.19
mg/L	0.15	0.00	0.15	0.11	0.00	0.11
PO_4	-0.8	-2.45*	0.8	-1.65	2.45*	1.65
mg/L	0.41	0.03	0.41	0.13	0.03	0.13
E.C.	-1.49*	-2.37*	1.49*	-0.88	2.37*	0.88
ms/cm	0.04	0.00	0.04	0.27	0.00	0.27
TS	-1.48	-2.40*	1.48	-0.92	2.40*	0.92
g/L	0.08	0.01	0.08	0.33	0.01	0.33
TSS	-0.74	-1.21*	0.74	-0.47	1.21*	0.47
g/L	0.13	0.03	0.13	0.39	0.03	0.39
TDS	-.75*	-1.19*	.75*	-0.44	1.19*	0.44
g/L	0.04	0.00	0.04	0.27	0.00	0.27
NaCL	-2.89*	-4.69*	2.89*	-1.8	4.69*	1.8
%	0.04	0.00	0.04	0.26	0.00	0.26
COD	-0.35	-8.55*	0.35	-8.19*	8.55*	8.19*
mgO_2/L	0.87	0.00	0.87	0.00	0.00	0.00

seasons might be due to the absence of aerators in 8/10 of ponds with minimizing surface water movement and the subsequent decreased mixing air O_2 into these ponds water .The higher TAN values recorded during hot period, might be attributed to the elevation of the water temperature and the increase in the evaporation rates and the accumulation of the dissolved salts in water . The relative increase in the ammonia during hot period may be attributed to the high evaporation rate, in addition to the denitrification process by the reduction of NO2 - and NO3- into NH3. (Abdo, 2005). Oxygen solubility was affected by salinity and impurities. Low dissolved oxygen in an aquaculture operation was at high concentration of biodegradable organic matter in the water which associated the high temperatures (Zelay et al., 2001). Tilapia could survive below 0.3 mg/L of DO and the aerator were so important to keep morning DO from falling below 0.7-0.8 mg/L when compared with non aerated ponds as reported by (Pumpa and Masser, 1999).

Table (20); the seasonal alteration didn't reveal significant differences in mean values of microbial load in all ponds except for Total Coliform Count which decreased significantly during spring Vs autumn (P= 0.003).

CONCLUSION

Spring season characterized by significant differences in values of TS, TSS, TDS, EC., Alkalinity., pH , PO_4^-, TAN, Salinity, COD, Hardness and Chlorides Vs autumn and

Table 20. Seasonal differences in microbial load.

Seasons	Spring		Summer		Autumn	
Parameters	Summer	Autumn	Spring	Autumn	Spring	Summer
T.Coli.C	-164.73	-368.77*	164.73	-204.03	368.77*	204.03
	0.13	0.05	0.13	0.09	0.05	0.09
T.C.C	645.29	450.69	-645.29	-194.60	-450.69	194.60
	0.31	0.52	0.31	0.78	0.52	0.78
T.F.C	669.65	1059.49	-669.65	389.84	-1059	-389.84
	0.29	0.13	0.29	0.58	0.13	0.58

summer. Spring had highest TFC in 6 /10 of ponds. Autumn showed highest values of Total Coliform Count in 7/10 of ponds. The seasonal alteration didn't reveal significant differences in values of microbial load in all ponds except for Total Coliform Count which decreased significantly during spring Vs autumn.

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