Assessment of Agriculture Drainage Water Quality to be Used for Fish Farm Irrigation

M. A. Osman[1], M. A. M. Mohamed[1], M. H. H. Ali[2] and A. D. G. Al-Afify[*2]

[1]Department of Biochemistry, Faculty of Agriculture, Cairo University Giza, Egypt
[2] National Institute of Oceanography and Fisheries. Inland Water Branch, Egypt (NIOF)
afifydardeir@yahoo.com[*]

Abstract: Water is the most important resource of a country, and of the entire society as a whole, since no life is possible without water. It has this unique position among other natural resources, like minerals, fuels, forests, live-stock etc. because a country can survive in the absence of any other resources, except this one. El-Serw Fish Farm situated on the southern west shore of Lake Manzalah near El-Serw navigation canal about 200 km Northeast Cairo. Agriculture drainage water quality, heavy metals, inorganic anions and pesticides distributions in water, sediment and fish were assessed in El-Serw Fish Farm seasonally during 2007. The obtained results indicated that, the concentrations of the most chemical parameters increased in the Outlet and decreased at the Inlet. Heavy metal and inorganic anions varied significantly ($P < 0.05$) depending upon the type of fish and location within the farm. Also, the order of occurrence of heavy metals and inorganic anions in water were ranked in the following order: Fe > Mn > Zn > Pb > Cu > Cd, while those in, the sediment were: Fe > Mn > Zn > Cu > Pb > Cd. Rank fish muscles of the two studied species of heavy metals concentrations in (*Tilapia zillii* and *Oreochromis niloticus*) were found in the order: Fe > Mn > Zn > Pb > Cu > Cd. The relative order of abundance of these elements can be summarized as follows: sediment > fish > water. One chlorinated hydrocarbon pesticides only were detected in one sediment sample. Data analysis indicated that, most the concentration levels of different determined parameters of the agricultural drainage water was found in the permissible limits for fish farms according to different standards. So, this water may be used as feeding source rearing fish. [Nature and Science 2010;8(8):60-74]. (ISSN: 1545-0740).

Key words: Agriculture drainage water quality, pollution, heavy metals, sediment, fish farm, pesticides.

1. Introduction

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes. Pollution of the aquatic environment by inorganic and organic chemicals is a major factor posing serious threats to the survival of aquatic organisms including fish (Saeed and Shaker, 2008). The agricultural drainage water containing pesticides and fertilizers and effluents of industrial activities and runoffs in addition to sewage effluents, supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals (ECDG, 2002). Most of the heavy metals become bound to particles in sediment, but a small quantity becomes dissolved in the water and can spread widely in the food chains (Khadr, 2005). Contamination of the aquatic environment with toxic elements is increased due to the progressive industrialization (Aboul-Ezz et al. 2002). Metal ions can be incorporated into food chains and concentrated in aquatic organisms to a level that affect their physiological state. In the Egyptian irrigation system, the main source of Cu and Pb are industrial wastes as well as algaecides for Cu, while that of Cd is the phosphatic fertilizers used in crop farms (Mason, 2002).

Aquaculture is considered as one of the most important sources of animal protein production for meeting the world's increasing demand for protein. The need to realize the maximum yield of all useable resources for food production is vital for over populated countries such as Egypt. This may be partly achieved by increasing the production of fish. This increase can be realized by increasing the area of cultured ponds and optimizing aquaculture methods (Magouz et al. 1999). Egypt's farms act as temporary reservoirs for drainage water highly contaminated with anthropogenic materials. Thus all coastal farms are subjected to an active process of contamination with different pollutants. El-Serw Fish Farm receives mainly drainage water from agricultural lands with little amount of industrial and sewage wastes (Al-Saad, 1995).

In a pond ecosystem, autotrophic producers convert elementary nutrients (e.g. C, N, P) into food nutrients (energy protein etc.) where production capacity is determined by the quantity of incident radiation, turbidity, water temperature and elementary nutrient. Limited availability of elementary nutrients in a natural pond can limit primary productivity, which can limit food nutrients for fish (Li and

Yakupitiyage, 2003).

Nowadays, the maintenance of these fish cultures out of pollution is of greatest concern. Moreover, the toxic effects of heavy metals and pesticides on farmed fish have imposed serious influences on human health. The agricultural drainage water is considered as one of the most important water sources to El-Serw Fish Farm. Consequently, the chemical analysis of the water supply, pond water and effluent water of the farm as well as the determination of some heavy metals and pesticides are of great importance to pond managers and consumers of aquatic products. Therefore, the aim of this work is to assess if the agriculture drainage water quality could meet the fish farm standard as well as its effect on fish quality.

2 - Materials and Methods

El-Serw Fish Farm is situated on the southern west shore of Lake Manzalah near El-Serw Navigation Canal about 200 km northeast Cairo. The farm was established in 1952 for experimental purposes and to compensate partially the deficiency of animal protein in Egypt. It was established on a piece of the lake which was reclaimed for agriculture. The farm was described by Abdel-Gawad, (1993) and Lotfy, (2001).

Samples collection

The water, sediment and fish samples were collected seasonally. Water samples were taken from the subsurface layer at depth of 30 cm in 2 L plastic bottles and transferred immediately in an ice-box to be analyzed. Samples were taken from three ponds, Inlet (agriculture drainage water which feeding source of El-Serw Fish Farm) and Outlet (Drainage of El-Serw Fish Farm) canals were selected to follow up the seasonal changes in the physico-chemical characteristics of the water, sediment and fish in the El-Serw Fish Farm during 2007 (Fig. 1).

Fig. 1. Illustration of different sites surveyed in El-Serw Fish Farm.

Methods of analyses

All physical and chemical analyses of water samples were measured according to (APHA, 1998), except biological oxygen demand (BOD) was determined according to Boyd (1973), nitrite was determined using colorimetric method and nitrate was determined by reduction method as described by Mullin and Riley, (1956).

Fe, Mn, Zn, Cu, Pb and Cd were measured in water, sediment and fish flesh of two species that were caught seasonally (*Oreochromis nilot*icus and *Tilapia zillii*) and major cations include (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} for water) and (Ca^{2+} and Mg^{2+} for sediment) samples during one year. The metals concentrations in different digested samples were determined using Atomic Absorption model (Perkin

Elmer 3110 USA) with graphite atomizer HGA-600 as described in APHA (1998), sediment and fish samples were digested according to Kouadia and Trefry (1987) and AOAC (1995) respectively.

Pesticide residues were extracted and prepared according to the methods of the Association of Official Analytical Chemists (AOAC, 1995). Aliquots of 1-2 µl of the final extracts were analyzed for pesticides residues at the central laboratories of the General Water Authority of Great Cairo using Hewlett-Packard Gas Chromatography model (6890) with detection limit for 13 chlorinated hydrocarbon pesticides approximately 0.01 ppb.

Statistical analysis

The comparison between means ± SE (standard errors) was tested for significance using one-way ANOVA analysis and Duncan's multiple range tests. The statistical analyses were calculated, using the computer program of SPSS Inc., (2001, version 10.0 for Windows) at $p < 0.05$.

3. Result and Discussion

The values of water temperature, salinity, DO, BOD, SO_4^{--}, NO_2^--N, NH_3-N and Na^+ showed non-significantly, while water transparency (Secchi-Disc), TS, EC, pH, COD, CO_3^{--}, HCO_3^-, Cl^-, NO_3^-, PO_4^{3-}, TP, K^+, Ca^{2+}, Mg^{2+} and (Ca^{2+}, Mg^{2+} for sediment) showed statistically significant differences between Inlet, Outlet and fish ponds at $P < 0.05$ (Table 1).

Fish farm activities include the application of artificial diet into fish ponds on a daily basis at a rate that could range between 10 – 40 kilograms/feddan/day. This amount of artificial diet is consumed by fish. The oxidation of food material during oxidative metabolism by fish results in the production of huge amounts of carbon dioxide in water. Boyd (1990) indicated that for each kilogram of feed applied in fish pond, 0.73 kilogram of organic matter in feed is execrated by fish in the form of metabolic wastes into the water. Much of the waste was in the form of carbon dioxide.

In aquaculture especially in semi-intensive systems, artificial feed has two main functions, (i) to be directly eaten by fish, and (ii) to supply nutrients to the environment, which in turn increases natural food availability (Rahman et al. 2006a) The major portion (≈ 80 %) of artificial feed is lost in the system as uneaten feed and faeces (Daniels and Boyd, 1989; Siddiqui and Al-Harbi, 1999). Artificial feed, which is lost in the system, has a great effect on water quality through decomposition (Horner et al. 1987; Poxton and Allouse, 1987; Poxton and Lloyd, 1989). But considerable nitrogen and phosphorus were included. The feed contains 5.76 % nitrogen and 1.26 % phosphorus on a dry weight basis (Boyd, 1982). Much of the surplus organic matter in feed is lost through the respiratory process. The artificial feed acts as a fertilizer, increasing the amount of natural food through the higher concentrations of nutrients (Dewan et al. 1988; Diana et al. 1997).

In pond culture, 21 % of the nitrogen and 19 % of the phosphorus (Siddiqui and Al-Harbi, 1999) in the artificial feed are retained by the fish. Another 14 % of the nitrogen and 21 % of the phosphorus dissolves and is used by phytoplankton (Neori and Krom, 1991). The remaining nitrogen and phosphorus mainly stimulates bacteria, fungi and protozoa production (Rahman et al. 2006b). Which in turn may be consumed by zooplankton (Tang, 1970; Langis et al. 1988).

Physico-chemical parameters of water play a significant role in the biology and physiology of fish (Dhawan and Kaur, 2002). Pond water had higher TS and TDS (1482 – 1624 and 887 - 1057 mgl^{-1}) compared to that of the Inlet water canal (972 and 689 mgl^{-1} respectively). TDS is a measure of the concentration of dissolved constituents in water. A certain level of these ions in water is essential nutrients for aquatic life (Galbrand et al. 2008). EC is a good indicator parameter on the total dissolved ions in aquatic ecosystem. The EC of ponds were had higher values 1467 – 2003 $\mu mhoscm^{-1}$ compared to that of the Inlet water canal 1273 $\mu mhoscm^{-1}$.

Most of the calcium in aquaculture pond sediments is associated with carbonate in the form of feebly soluble calcium carbonate. The average carbonate content in the sediments of Lake Manzalah is 34.88 % (El-Wakeel et al. 1970). Calcium carbonate content in surficial sediment of Lake Borollus ranged 15 – 44 % (El-Deek et al. 1995). The huge production of metabolic of weakly soluble calcium carbonate in sediments by carbonic acid into highly soluble calcium bicarbonate. The latter compound dissolve and rise from sediments to surface water increasing total alkalinity in the from of HCO_3^-. This phenomenon resulted in the decrease in calcium content in sediment of fish ponds (2.6 – 3.0 mgg^{-1}) compared to those of the Inlet and Outlet sediments (3.7 – 4.2 mgg^{-1}) where no artificial feed are applied.

The same process affected Mg^{2+} content in sediments. Magnesium is usually the second most abundant cation in inland waters. Its source is both silicate and non-silicate minerals of the earth's crust. One such as forsterite ($MgSiO_4$) can be altered by carbonic acid produced from dietary CO_2 to from silica and magnesium carbonate ($MgCO_3$). This carbonate can be dissolved further by carbonic acid in the same manner as limestone to form magnesium

Table 1. Average physico-chemical parameters of different sites in water and sediments at El-Serw Fish Farm

Site / Parameter	Inlet	Pond (1)	Pond (11)	Pond (16)	Outlet	[1]Fish Farm Standard
A) Mineral contents						
TS mgl^{-1}	$972^{c} \pm 49.6$	$1482^{b} \pm 10.6$	$1543^{ab} \pm 56.6$	$1624^{ab} \pm 94.8$	$1762^{a} \pm 98.8$	
TDS mgl^{-1}	$689^{b} \pm 30.9$	$887^{ab} \pm 5.5$	$893^{ab} \pm 49.5$	$1057^{a} \pm 101$	$1102^{a} \pm 88.3$	
EC µmhos cm^{-1}	$1273^{c} \pm 9.7$	$1467^{c} \pm 8.1$	$1823^{b} \pm 48.7$	$2003^{ab} \pm 77.9$	$2289^{a} \pm 90$	750 - 2500
Salinity (‰)	$0.72^{a} \pm 0.0\ 3$	$0.85^{a} \pm 0.06$	$1.05^{a} \pm 0.06$	$1.20^{a} \pm 0.02$	$1.26^{a} \pm 0.05$	< 0.5 ‰
CO_3^{--} mgl^{-1}	$5.0^{b} \pm 2.0$	$13.8^{ab} \pm 4.2$	$19.5^{a} \pm 4.0$	$24.9^{a} \pm 5.0$	$16.5^{ab} \pm 5.3$	
HCO_3^{-} mgl^{-1}	$142^{b} \pm 7.6$	$157^{b} \pm 5.3$	$188^{b} \pm 21.4$	$241^{a} \pm 14.0$	$254^{a} \pm 21.5$	100
Cl^{-} mgl^{-1}	$260^{c} \pm 4.43$	$319^{c} \pm 24.3$	$449^{b} \pm 41.3$	$516^{ab} \pm 3.5$	$563^{a} \pm 30.8$	
SO_4^{--} mgl^{-1}	$92.2^{a} \pm 2.5$	$119^{a} \pm 13.4$	$116^{a} \pm 4.8$	$119^{a} \pm 17.0$	$117^{a} \pm 20.4$	< 50
Na^{+} mgl^{-1}	$113^{a} \pm 23.5$	$128^{a} \pm 28.3$	$143^{a} \pm 22.4$	$149^{a} \pm 22.4$	$157^{a} \pm 35.2$	< 200
K^{+} mgl^{-1}	$11.0^{c} \pm 1.0$	$13.0^{bc} \pm 0.8$	$16.2^{abc} \pm 1.5$	$17.4^{ab} \pm 2.7$	$19.3^{a} \pm 1.8$	
Ca^{2+} mgl^{-1}	$46.9^{a} \pm 2.9$	$37.3^{ab} \pm 8.3$	$29.7^{ab} \pm 6.1$	$25.5^{b} \pm 4.8$	$31.9^{ab} \pm 7.3$	75 - 150
Mg^{2+} mgl^{-1}	$54.0^{c} \pm 5.0$	$67.9^{bc} \pm 3.0$	$89.3^{ab} \pm 12$	$106.4^{a} \pm 14.9$	$101.5^{a} \pm 7.0$	30 - 150
Sediment (mgg^{-1}) Ca^{2+}	$3.7^{b} \pm 0.2$	$3.0^{c} \pm 0.1$	$3.0^{cd} \pm 0.1$	$2.6^{d} \pm 0.1$	$4.2^{a} \pm 0.1$	
Sediment (mgg^{-1}) Mg^{2+}	$3.1^{b} \pm 0.6$	$2.6^{c} \pm 0.5$	$2.5^{c} \pm 0.6$	$2.2^{d} \pm 0.1$	$3.6^{a} \pm 0.1$	
B) Micronutrients dynamics						
W. temp. ^{0}C	$24.0^{a} \pm 2.9$	$24.8^{a} \pm 3.4$	$24.2^{a} \pm 2.9$	$24.7^{a} \pm 3.0$	$24.2^{a} \pm 2.9$	12 - 30
Trans. cm	$22.5^{a} \pm 3.2$	$16.3^{ab} \pm 1.7$	$14.8^{b} \pm 1.5$	$13.0^{b} \pm 2.0$	$11.8^{b} \pm 1.8$	30 - 40
pH	$8.1^{b} \pm 0.2$	$8.5^{ab} \pm 0.1$	$8.6^{a} \pm 0.1$	$8.4^{ab} \pm 0.1$	$8.4^{ab} \pm 0.1$	6.0 – 9.0
DO mgl^{-1}	$8.1^{a} \pm 0.4$	$7.3^{a} \pm 0.7$	$6.7^{a} \pm 0.7$	$7.0^{a} \pm 2.7$	$5.9^{a} \pm 0.9$	≥ 5
BOD $mgl^{-1}day^{-1}$	$2.5^{a} \pm 0.8$	$6.6^{a} \pm 1.9$	$7.4^{a} \pm 1.6$	$7.1^{a} \pm 1.5$	$8.1^{a} \pm 2.0$	≤ 5
COD mgl^{-1}	$25.9^{b} \pm 4.5$	$67.5^{a} \pm 12.0$	$80.4^{a} \pm 5.9$	$73.8^{a} \pm 4.3$	$91.8^{a} \pm 13.6$	< 25
NO_2^{-} mgl^{-1}	$0.06^{a} \pm 0.02$	$0.04^{a} \pm 0.01$	$0.04^{a} \pm 0.02$	$0.04^{a} \pm 0.01$	$0.04^{a} \pm 0.02$	< 0.3
NO_3^{-} mgl^{-1}	$0.13^{a} \pm 0.02$	$0.07^{ab} \pm 0.03$	$0.08^{ab} \pm 0.02$	$0.06^{b} \pm 0.02$	$0.06^{b} \pm 0.02$	< 0.5
NH_3 mgl^{-1}	$1.9^{a} \pm 0.6$	$2.1^{a} \pm 0.3$	$1.5^{a} \pm 0.8$	$1.2^{a} \pm 0.3$	$1.6^{a} \pm 0.4$	0.02 – 1.0
PO_4^{3-} mgl^{-1}	$0.21^{a} \pm 0.02$	$0.10^{b} \pm 0.04$	$0.11^{b} \pm 0.03$	$0.12^{b} \pm 0.07$	$0.12^{b} \pm 0.03$	
TP mgl^{-1}	$0.34^{c} \pm 0.06$	$0.73^{ab} \pm 0.02$	$0.43^{bc} \pm 0.05$	$0.63^{abc} \pm 0.07$	$0.79^{a} \pm 0.11$	

1: Meade, (1989) Mean ± Standard Error Mean in the same row with different letters are significantly different (Duncan multiple range test $P < 0.05$).

bicarbonate (Cole, 1979). This reaction resulted in the decrease of magnesium content in pond sediments (2.2 – 2.6 mgg^{-1}) compared to those of the Inlet and Outlet (3.1 – 3.6 mgg^{-1}) due to the heavy application of artificial diet in pond water. The Inlet and Outlet canal didn't receive dietary inputs in contrast to fish ponds lowering metabolic CO_2 production in these canals.

The dissolution of magnesium carbonate in sediments into highly soluble magnesium bicarbonate resulted in the increase in magnesium cation in pond water (67.9 – 106.4 mgl^{-1}) compared to that of the Inlet (54 mgl^{-1}). In the same time, bicarbonate concentration in fish ponds increased to 157 – 241 mgl^{-1} compared to that of the Inlet (142 mgl^{-1}). Since calcium concentration in pond waters did not increase compared to that of the Inlet water, the huge increase in bicarbonate contents in pond waters could be due to the increase in magnesium bicarbonate concentrations but not calcium bicarbonate concentrations.

The concentration of calcium cation was lower in water in fish ponds (25.5 – 37.3 mgl^{-1}) compared to that of the Inlet (46.9 mgl^{-1}) due to the high biological activity of algae in fish ponds compared to that of the Inlet. Calcium usually surpasses magnesium in fresh waters because there is a preponderance of calcium over magnesium in sedimentary rocks. With evaporation and resultant concentration, however, magnesium may assume more importance. This is because the loss of free CO_2 and the rise in pH, accompanied by some evaporation, cause precipitation of $CaCO_3$, while magnesium compounds remain in solution (Cole, 1979). The same process resulted in a huge increase of magnesium concentration in water in fish ponds (67.9 – 106.4 mgl^{-1}) over that of calcium (25.5 – 37.3 mgl^{-1}), although calcium and magnesium concentrations in Inlet water (46.9, 54.0 mgl^{-1} respectively) were nearly equal.

The sodium cation contents in pond water (128 – 159 mgl^{-1}) were higher than that of the Inlet (113 mgl^{-1}). Moreover, the chloride anion cations in pond water were greatly higher (319 – 516 mgl^{-1}) compared with that of the Inlet water (260 mgl^{-1}). The concentrations of chloride anion pond water represented 37.5 – 43.0 % of total salinity (0.85 – 1.20 ‰). When examining the major source of such great increase in chloride contents of pond water compared to that of the Inlet, it is evident that sodium chloride in bottom muds (saline sediment) was the main source of such great increase in both chloride and sodium ions in pond water.

Data analysis indicated that the main salt dissolved from bottom mud into pond water was sodium chloride which produced a significant increase in both sodium and chloride ions in surface water. This possibility arises from the inspection of the concentrations sodium, potassium, calcium and magnesium in pond water compared with those of the Inlet. The only major increase in cation contents in pond water compared to those of the Inlet water was due to the increase in sodium and magnesium cations. Since there was a parallel increase in bicarbonate content in pond water along with the increase in chloride contents, this indicated that sodium chloride in pond sediments was the main source of the great increase in chloride anion in pond water. Magnesium bicarbonate was expected to be the major source the great increase of bicarbonate contents in pond water when compared to that of the Inlet water.

Pond water had higher SO_4^{--} (116 – 119 mgl^{-1}) compared to that of the Inlet water canal (92 mgl^{-1}). Sulfates effect on aquatic organisms is rarely obvious, although there are times when it may be a limiting factor in growth. The amino acids containing the sulfhydryl groups are normal in plant protein, and for this reason, sulfur deficiency can inhibit algal populations, perhaps by hindering chlorophyll synthesis in some way. Probably in most instances, however, the sulfates are more than adequate for freshwater productivity (Cole, 1979).

Waters in earthen ponds fish farm can be classified as intermediate mixtures of chloride, carbonate and sulfate waters, with the predominance of chloride salts. Chloride waters in earthen ponds owe their composition to the leaching of bottom soils and sediments in El-Serw Fish Farm. This is the only reasonable explanation of the high relative chloride contents in pond water compared to that of the Inlet water. Sodium and magnesium were the dominant cations in pond water, being more soluble. The great increase in ionic concentrations of magnesium and bicarbonate in pond waters was probably due to biological activity in water. The main cation in pond water was sodium while the main anion in pond water was chloride. Both constituted 52.5 – 55.4 % of total salinity among ponds. Were chloride is most abundant, most of it combines with sodium. The soils are sources of edaphic ions. The mechanisms that release these ions are solution, including complexities of solubility differences. Among limnologists the term salinity refers to the sum of anion and cations, salinity can be determined by measuring electrical conductivity (Cole, 1979).

The speed of bottom currents over bottom muds increases with the increase of surface water area in pond (fetch) and the velocity and strength of bottom currents. Larger ponds tend to have strong and high speed bottom currents than smaller ponds. Consequently, bottom currents in larger ponds tent to violently agitate bottom soil, dissolved more mineral salts from bottom sediments compared to those in smaller ponds. Large ponds produce much longer and higher waves compared to small ponds. In shallow wide ponds the effect of the wind on the lee side is to produce return currents that ideally curve around the sides and bottom of the pond.

Since bottom currents are more stronger in larger pond than smaller ponds. These currents were able to dissolve more mineral salts present in bottom muds in larger ponds compared to small ponds, specially sodium chloride and magnesium bicarbonate which formed most of anion and cation contents of water. This can justify the variation in water salinity among ponds compared to that of the Inlet water. The least salinity (0.72 gl^{-1}) was observed in the Inlet water, while salinity of water was highest in pond (16) (Salinity 1.2 pond area ≈ 3 feddans), medium in pond (11) (salinity = 1.05 ‰- pond area ≈ 2 feddans) and small in pond (1) (salinity = 0.85 ‰ and pond area ≈ one feddans). This variation in salinity of water was due to the greater water friction over bottom muds by return currents in larger ponds compared to small ponds. These frictional forces of water help dissolve more mineral salts from bottom muds especially sodium chloride and magnesium bicarbonate. The latter results from the reaction between CO_2 and bottom sediments.

Higher alkalinities were observed in larger ponds (Pond (11) and (16)) than in the Inlet water throughout the experimental period, which might be due to the high rate of CO_2 production in ponds than that in the Inlet water. Knud-Hansen (1998) mentioned that long term increase in alkalinity in ponds treated with organic matter has been associated with the release of CO_2 from the decomposition of organic material (commercial feed).

Studies conducted else where, indicated that a pond's total alkalinity was significantly greater where organic fertilization and feeds were applied (Kumar et al. 2005). Alkalinity increases with feeding and organic fertilization because bacterially generated CO_2 from feed metabolism and manure decomposition dissolves calcium and magnesium carbonate present in the pond sediments (Boyd, 1990). The variation in alkalinity over time may be due to a change in rate of metabolism, respiration (CO_2 production) and feeding habitat of the fish species as they grow (Kumar et al. 2005).

Yields of Nile tilapia in fertilized ponds are positively correlated to net primary productivity (Knud-Hansen et al. 1993; Lin et al. 1997), which was linearly correlated to total alkalinity (Knud-Hansen et al. 1993), implying that availability of natural food in ponds is positively correlated to net primary productivity (Yi, 1998). Yi (1998) indicated that growth of fish was greater in ponds with higher alkalinity.

The average of water temperature in El-Serw Fish Farm ranged between 24.0 – 24.8 ^{0}C. This average water temperature indicates a good potential of fish production since high fish harvest could be obtained under warm water fish culture conditions. The optimum temperature range for many species of warm water fishes is 24 to 30 ^{0}C. Water slight warmer than optimum provides better growth and food conversion than low temperature (Chaudhari, 2003).

In pond water transparency appeared at a low level (13.0 – 16.3 cm) compared to that of the Inlet water (22.5 cm). Rahman et al. (2006b) indicated that, feeding lowered secchi disc visibility (SDV) in water in earthen ponds. The concentrations of chl-a (algae abundance) and TSS were higher in fed ponds. In fish ponds, secchi disc transparency provides a rough estimate of plankton abundance. Water transparency showed an increase correlation to plankton abundance (Padmavathi and Prasad, 2007). Nyandat (2007) reported that most farmers monitor algal blooms is don by using secchi disc depth. Ponds are fertilizer when secchi disk exceeds 15 cm.

Secchi disk visibility (SDV) is commonly used by aquaculture pond managers as an indicator of phytoplankton concentration. Pond managers often have arrange of SDV values within which they try to maintain their pond, and they may alter fertilization, water exchange rates, or take other management actions to meet their SDV goals. In addition, SDV measurements may be used in modeling phytoplankton productivity when more direct phytoplankton concentration measurements are not available. Therefore, it is desirable that a quantitative treatment of the relationship between SDV measurements and chlorophyll a (chl-a) concentrations be carried out (Jamu et al. 1999).

Almazan and Boyd (1978) produced one such relationship for aquaculture ponds where phytoplankton was the major source of turbidity. However, in aquaculture ponds, organic matter, color of humic substances and inorganic materials like suspended clay may also be significant sources of turbidity (Jamu et al. 1999). A majority of aquaculture ponds receive high inputs of organic matter in the form of food or organic fertilizers (Edwards, 1987; Schroeder et al. 1991; Chien, 1992).

In such systems, non-phytoplankton sources of turbidity can be significant such that the Almazan and Boyd (1978) relationship may be inappropriate. This was recognized by Almazan and Boyd (1978) who cautioned against the use of SDV as an indicator of phytoplankton concentration unless plankton is the primary cause of turbidity.

In pond aquaculture, SDV measurements and/or water color are often used to determine success of fertilization regimes or as an index of phytoplankton production (e.g., Almazan and Boyd, 1978). As suggested by Almazan and Boyd (1978) and Koenings and Edmundson (1991), this application of SDV may be appropriate only when the non-algal turbidity of the water. Under those conditions, SDV changes can be attributed to changes in chla (Chl-a) and SDV measurements can be used reliably as indicators of chla (and phytoplankton) concentration in a pond Jamu et al. (1999).

Pond water had higher pH (8.4 – 8.6) compared to that of the Inlet water canal (8.1). Padmavathi and Prasad (2007) indicated that high pH levels in pond water are associated with algal blooms. The pH at which dense algal blooms observed was 9.2 – 9.4. High pH, indicating excessive alkalinity, can also be harmful. However, it should be noted that in productive water pH may reach higher values of 9 to 10 the uptake of carbon dioxide during photosynthesis in the daily pH cycle. This is why is be better to take pH measurements before daybreak to determine their suitability for aquaculture. A pH level of 11 may be lethal to fish (Chaudhari, 2003).

In the present study, the physico-chemical parameters remained within favourable ranges for fish growth and survival. Dissolved oxygen (DO) can be said to be the most important among the water quality parameters without which fish production is impossible. Desirable concentration of dissolved oxygen for most fish is 5 mgl^{-1} and above (Bwala and Omoregie, 2009). In pond water DO concentrations appeared at a low level (6.7 – 7.3 mgl^{-1}) compared to that of the Inlet water (8.1 mgl^{-1}). This could be due to its considerable depletion from fish respiration and heterotrophic decomposition (by bacteria) (Li and Yakupitiage, 2003).

Biological activities in larger ponds (Pond (11) and (16)) were higher in terms of biological oxygen demand (BOD) and chemical oxygen demand (COD) which ranged 7.1 – 7.4 $mgl^{-1}day^{-1}$ and 73.8 – 80.4 mgl^{-1}, respectively. While, biological activities in the Inlet water canal were lowest in terms of BOD (2.5 $mgl^{-1}day^{-1}$) and COD (25.9 mgl^{-1}). The higher photosynthetic activities of algae are positively correlated with the magnitude of BOD and COD. The increased photosynthetic and biological activities in larger ponds consumed much higher amounts of ammonia as micronutrient with increased photosynthetic activities of algae compared to that of the Inlet water.

The biochemical oxygen demand (BOD) of pond water results from the respiration of plankton and bacteria. Boyd (1973) reported that the BOD in fertilized and fed ponds at Auburn University ranged from 0.02 to 0.33 mg/liter per hour with an average of 0.14 mg/liter per hour. Later studies (Boyd et al. 1978) revealed that BOD in some catfish ponds reached 0.7 mg/liter per hour. Magnitudes of BOD values depended upon temperature, density of plankton, concentration of organic matter, and related factors (Boyed 1979, 1990).

Standard BOD measurements are not generally meaningful to fish culturists because most of BOD of pond water sample results from plankton respiration, rather than from the decomposition of organic waste (Boyd, 1982).

Pond water had higher COD (67.5 – 80.4 mgl^{-1}) compared to that of the Inlet water canal (25.9 mgl^{-1}). The rate of removal of O_2 by organisms is measured through the biological oxygen demand which reflects the biological activities in water. The oxygen consumed during algal respiration is included and, in some cases, this may account for up to 50 % of the total BOD. The amount of organic matter in pond water (including aquatic organisms, algae - zooplankton - bacteria) can be estimated by COD procedure (Golterman et al. 1978).

Boyd (1973) found the COD of pond waters to be closely correlated with algae concentration, suggesting that phytoplankton was a major contributor to COD. Since plankton is a major source of turbidity in may fish ponds, the secchi disk visibility provides an estimated of plankton density (Almazan and Boyd, 1978). There is also a high correlation between secchi disk visibility and the COD of pond waters (Boyd et al. 1978).

In ponds receiving protein-rich pellets only 11 - 35 % of the supplied N and 13 – 36 % of P were retained in fish biomass. A large fraction of the unused N and P accumulated in the system affecting water quality in the overlaying water column. Sediment can store 100 - 1000 times more nutrients than water (Biro, 1995).

Higher amounts of nitrogenous and phosphorus compounds enhanced photosynthesis, explaining the higher plankton production, higher TSS values and lower transparency in fed treatments compared to non-fed treatments (Poxton, 1991; Milstein and Svirsky, 1996; Moriarty, 1997 and Rahman et al. 2006c).

In pond water NO_2^- and NO_3^- concentrations were appeared at a low level (0.04 and 0.06 – 0.08 mgl^{-1}) compared to that of the Inlet water (0.06 and 0.013 mgl^{-1}, respectively). Lower total ammonia (TAN) concentrations in larger ponds (1.2 – 1.5 mgl^{-1}) compared to than of Inlet water (1.9 mgl^{-1}) could be attributed to the higher photosynthetic activities of algae in larger ponds supported by feeding practices.

Soluble reactive phosphorus concentrations in pond water (0.1 – 0.12 mg/l) were lower than that of the Inlet water (0.2 mg/l). This could be attributed to the higher photosynthetic activities of algae in pond water supported by the fertilization and feeding activities. The increased photosynthetic activities of algae in pond water helped deplete soluble reactive phosphorus lowering PO_4^{3-} concentrations.

Orthophosphate concentrations are only a small fraction (usually < 10 %) of total phosphorus concentrations. For practical purposes, the difference between total phosphorus and filterable orthophosphate concentrations may be used as an index of the phosphorus contained in plankton and detritus. Fish and other macroscopic organisms have fairly high concentrations of phosphorus, and their combined biomass contains a rather large amount of phosphorus (Boyd, 1982).

It was found that PO_4-P and NO_3-N were strongly positively correlated with phytoplankton and zooplankton biomass. PO_4-P had the strongest overall correlation with phytoplankton density and with natural food availability is general. The correlation between PO_4-P and total phytoplankton biomass was stronger in treatments without CC ($r = 0.64$, $P < 0.01$), which might indicate that phytoplankton biomass was limited by PO_4-P concentrations (Rahman et al. 2008).

Rahman et al. (2008) indicated that all groups of phytoplankton and zooplankton in the pond water were positively correlated with all nitrogen and phosphorus species and TSS, where as negatively correlated with total alkalinity, pH and DO concentration.

Total phosphorus concentrations were higher in pond water (range 0.43 – 0.73 mg/l) than that of the Inlet water canal (0.34 mg/l). Total phosphorus is considered as an index for phytoplankton abundance in water since it includes organic sestonic phosphorus and organic soluble phosphorus and soluble reactive phosphorus. Seston concentration is associated with phytoplankton abundance in water (Hutchinson, 1975).

The drastic increase in total phosphorus concentration in pond water were attributed to the high phytoplankton abundance and aquatic organisms in pond water compared to those of the Inlet water canal since TP measure organic sestonic phosphorus of which algae concentration contribute a major portion. The increased algae concentrations in pond water are mainly due to the high fertilization and feeding activities in pond water but not the Inlet canal.

The ratio of total phosphorus : soluble reactive phosphorus was between 4.3 : 1 and 6.1 : 1. The difference in concentrations of total phosphorus and soluble reactive phosphorus represents the concentration of phosphorus in phytoplankton and other particulate matter (Wudtisin and Boyd, 2005). Consequently, total phosphorus concentration in pond water could be considered as an index to the phytoplankton abundance in water.

Aquaculture ponds receiving feeds often have total phosphorus concentrations above 0.5 mg/l and total nitrogen concentrations of 2 or 3 mg/l (Boyd and Tucker 1998). Soluble reactive phosphorus and total phosphorus concentrations were both correlated with fish production (Wudtisin and Boyd, 2005).

Sin (1987) indicated that higher growth rate of fish corresponded with the increase in planktonic life which showed their maximum densities at high phosphate concentration of the water.

Statistical analysis showed that there were significant differences for overall mean concentrations of nitrate (NO_3^-), total phosphorus (TP) and pH values among different sites in El-Serw Fish Farm ($P < 0.05$). Nutrient assessment can be based on total nitrogen and total phosphorus measurements and plankton abundance can be followed using secchi disk visibility measurements (Boyd, 1982 and Wudtisin and Boyd, 2005).

Major of the agriculture drainage water quality parameters (ADWQ) measured during the study remained in the favorable range for tilapia (Boyd, 1990 and Thakur et al. 2004), suggesting that tilapia growth performance was not limited by any of the water quality parameters.

The concentrations of heavy metals in water (Mn, Zn, Cu and Pb) showed significant differences while (Fe and Cd) showed non-significantly at $P < 0.05$ (Table 2). Analysis of heavy metals concentrations in five different sites in El-Serw fish farm, namely iron, manganese, zinc, copper, lead and cadmium are illustrated in Table (2) in terms of means and standard errors. The average concentrations of dissolved heavy metals (Fe, Mn, Zn, Cu, Pb and Cd) in water ranged 1040 – 1228, 80 – 145, 50.6 – 90.4, 16.0 – 27.8, 20.9 – 34.9 and 2.5 – 4.4 μgl^{-1}, respectively. These concentrations were lower than the standard permissible limits according to Meade (1989) except for those of Fe and Zn. The inspection of heavy metals loads in water at El-Serw Fish Farm indicated that there was a slight enrichment of iron (1040 – 1228 μgl^{-1}) and zinc (50.6 – 90.4 μgl^{-1}) when compared to the standard permissible limits in water (< 1000 and 50 μgl^{-1}, respectively).

It is clear from above mentioned result that the distribution of heavy metals in fish farm's water showed an elevated values at Outlet where generally subjected to wastes coming from the fish ponds. However, Inlet (feeder) was maintained the lowest average values of metals which attributed to uptake of different metals by the dense aquatic plants found in the banks (Ali and Abdel-Satar, 2005).

Drain water of the Nile Delta have dissolved

Table 2. Annual sites average of heavy metal concentrations in water, sediment and fish flesh at El-Serw Fish Farm

Site / Parameter		Inlet	Pond (1)	Pond (11)	Pond (16)	Outlet	Permissible limits
1 – Water (mgl^{-1})							**Meade, (1989)**
Fe μgl^{-1}		$1040^{a} \pm 75$	$1228^{a} \pm 75$	$1152^{a} \pm 34$	$1112^{a} \pm 57$	$1198^{a} \pm 46$	< 1000
Mn μgl^{-1}		$104^{b} \pm 3.0$	$85^{bc} \pm 3.6$	$97^{bc} \pm 4.5$	$80^{c} \pm 5.5$	$145^{a} \pm 12.0$	50 - 500
Zn μgl^{-1}		$50.6^{c} \pm 1.7$	$83.3^{ab} \pm 3.6$	$58.1^{c} \pm 2.7$	$66.5^{bc} \pm 3.8$	$90.4^{a} \pm 12.7$	50
Cu μgl^{-1}		$16.0^{b} \pm 1.4$	$17.8^{b} \pm 1.3$	$20.0^{b} \pm 1.2$	$18.2^{b} \pm 1.2$	$27.8^{a} \pm 1.7$	30
Pb μgl^{-1}		$20.9^{c} \pm 1.6$	$28.8^{b} \pm 2.1$	$26.0^{bc} \pm 2.4$	$28.0^{b} \pm 1.5$	$34.9^{a} \pm 1.4$	50
Cd μgl^{-1}		$2.6^{a} \pm 0.3$	$2.5^{a} \pm 0.4$	$3.5^{a} \pm 0.5$	$3.6^{a} \pm 0.5$	$4.4^{a} \pm 1.0$	10 - 30
2 – Sediment (μgg^{-1})							**OMOE, (1993)**
Fe μgg^{-1}		$2944^{ab} \pm 136$	$2386^{bc} \pm 87$	$2213^{c} \pm 151$	$1955^{c} \pm 64$	$3051^{a} \pm 380$	20000 - 40000
Mn μgg^{-1}		$301^{b} \pm 12$	$269^{bc} \pm 15$	$235^{cd} \pm 18$	$192^{d} \pm 14$	$413^{a} \pm 26$	460 - 1110
Zn μgg^{-1}		$79^{b} \pm 3.0$	$69^{b} \pm 8.0$	$66^{b} \pm 2.4$	$64^{b} \pm 4.7$	$112^{a} \pm 3.8$	120 - 820
Cu μgg^{-1}		$25.0^{b} \pm 1.0$	$24.0^{b} \pm 1.4$	$22.0^{b} \pm 0.8$	$20.3^{b} \pm 1.2$	$37.8^{a} \pm 1.7$	16 - 110
Pb μgg^{-1}		$17.9^{a} \pm 2.2$	$25.8^{a} \pm 3.8$	$20.0^{a} \pm 1.9$	$17.8^{a} \pm 2.0$	$20.9^{a} \pm 1.5$	13 - 250
Cd μgg^{-1}		$3.3^{b} \pm 0.1$	$2.9^{b} \pm 0.2$	$2.6^{bc} \pm 0.2$	$2.1^{c} \pm 0.2$	$4.4^{a} \pm 0.4$	0.6 - 10
3 – Fish (μgg^{-1})							**FAO, (1992)**
Fe μgg^{-1}	***O.n***	$66^{ab} \pm 7.6$	$56^{ab} \pm 6.8$	$62^{ab} \pm 5.7$	$53^{b} \pm 3.2$	$74^{a} \pm 3.8$	30.0
	T.z	$69^{a} \pm 7.3$	$69^{a} \pm 8.3$	$71^{a} \pm 6.6$	$65^{a} \pm 3.0$	$66^{a} \pm 3.7$	
Mn μgg^{-1}	***O.n***	$32^{ab} \pm 2.7$	$30^{ab} \pm 2.8$	$30^{ab} \pm 1.6$	$26^{b} \pm 1.1$	$36^{a} \pm 1.9$	30.0
	T.z	$34^{a} \pm 2.8$	$34^{a} \pm 3.0$	$34^{a} \pm 2.1$	$33^{a} \pm 2.5$	$34^{a} \pm 3.6$	
Zn μgg^{-1}	***O.n***	$27^{a} \pm 2.5$	$27^{a} \pm 0.8$	$29^{a} \pm 0.8$	$24^{a} \pm 0.8$	$28^{a} \pm 1.8$	40.0
	T.z	$29^{a} \pm 1.7$	$28^{a} \pm 0.8$	$31^{a} \pm 0.9$	$30^{a} \pm 1.3$	$32^{a} \pm 2.3$	
Cu μgg^{-1}	***O.n***	$11^{a} \pm 0.81$	$10^{a} \pm 1.1$	$10^{a} \pm 0.8$	$9^{a} \pm 0.55$	$11^{a} \pm 0.7$	20.0 – 30.0
	T.z	$11^{a} \pm 0.8$	$11^{a} \pm 0.8$	$11^{a} \pm 0.5$	$10^{a} \pm 0.4$	$11^{a} \pm 1.1$	
Pb μgg^{-1}	***O.n***	$12^{ab} \pm 0.4$	$11^{b} \pm 0.4$	$13^{ab} \pm 1.0$	$12^{ab} \pm 1.5$	$14^{a} \pm 0.4$	2.0
	T.z	$13^{a} \pm 0.4$	$13^{a} \pm 1.0$	$13^{a} \pm 0.8$	$12^{a} \pm 0.4$	$13^{a} \pm 1.2$	
Cd μgg^{-1}	***O.n***	$1.9^{a} \pm 0.2$	$1.2^{a} \pm 0.2$	$2.1^{a} \pm 0.2$	$1.4^{a} \pm 0.4$	$2.1^{a} \pm 0.1$	2.0
	T.z	$2.2^{a} \pm 0.3$	$2.0^{a} \pm 0.3$	$2.4^{a} \pm 0.2$	$1.9^{a} \pm 0.9$	$1.8^{a} \pm 0.2$	

Mean ± Standard Error ***O.n***: *Oreochromis niloticus* ***T.z***: *Tilapia zillii*
Mean in the same row with different letters are significantly different (Duncan multiple range test $P < 0.05$).
OMOE, (1993) guideline (LEL – SEL) LEL: Lowest Effect Level SEL: Severe Effect Level

humic substances in their surface water which can be considered as sites for heavy metals storage (El-Sayed et al. 1993). Humic acids present in sediment are organic substances that enhance the accumulation of heavy metals in bottom sediments (El-Sayed et al. 1991). These humic acids may incorporate an important portion of trace metals. The concentration of humic substances may account for a high amount of total organic carbon present in bottom sediments especially as humic and fulvic acids (Wafica, 1994). These organic acids contain most of heavy metals pollution in sediments. The latter author indicated that most abundant heavy metals present in the humic acids were Fe, Mn, Zn, Cu, Pb and Cd. El-Serw Fish Farm receives its Inlet water from water drains. The drain water is contaminated with sewage and industrial wastes which are discarded constantly into the Delta basins and fish farms (Saad, 1983; Samaan and Abdelmonem, 1986).

Concentrations of (Fe, Mn, Zn, Cu and Cd) in sediment differed significantly while (Pb) showed non-significantly. Heavy metals accumulations in surficial sediments of El-Serw Fish Farms were within the standard permissible limits in terms of fish farming activities (OMOE, 1993). Low sediment enrichment were found for Fe (1955 – 3051 μgg^{-1}), Mn (192 – 413 μgg^{-1}), Zn (64 – 112 μgg^{-1}), Cu (20.3 – 37.8 μgg^{-1}), Pb (17.8 – 25.8 μgg^{-1}) and Cd (2.1 – 4.4 μgg^{-1}).

The heavy metals and pesticides which are poisonous to man and fish are stored in water and bottom sediments. These toxic compounds are bound to several fractions, namely, the organic matter bound fraction, carbonate bound fraction and oxides and chlorides of heavy metals (El-Deek et al. 1995). El-Serw Fish Farm is located near Lake Manzalah where the sediments contain 34.9 % carbonate (El-Wakeel et al. 1970) and 6.4 % organic matter contents (El-Sabrouti et al. 1997). Samaan and Abdelmonem (1986) reported that the polluted basins of Delta Lakes receive most of water from water drains which are contaminated with sewage and industrial wastes. According to Siegal et al., (1994), industrial and sewage wastes containing potentially toxic metals are dumped into the Nile Delta drain system located near Lake Manzalah.

The concentrations of (Fe, Mn and Pb) were significantly differences in fish flesh of *Oreochromis nilot*icus while (Zn, Cu and Cd) showed non-significant but *Tilapia zillii* showed statistically non-significant differences between Inlet, Outlet and fish ponds for all studied metals (at $P < 0.05$).

High contents of Fe and Pb in fish flesh reached up to 74 and 14 μgg^{-1}, respectively. Fe and Pb concentrations in fish flesh range: (53 – 74 and 12 – 14 μgg^{-1}) were approximately two folds and seven folds, respectively, in comparison to the standard permissible limits according to human health standards (30 and 2 μgg^{-1}), respectively, FAO (1992).

Other heavy metals concentrations in fish flesh (Mn, Zn, Cu and Cd) were low. As a result, environmental pollution with these heavy metals does not impose any threat on human health in terms of safety of aquatic products, according to FAO (1992) standards. According to Allen-Gill and Martynov (1995), low levels of copper and zinc (9 – 11 and 24 – 32 μgg^{-1}, respectively) in fish muscles appear to be due to low levels of binding proteins in the muscles.

The accumulation trends of the heavy metals in muscles of both species of Tilapia were found in the order of Fe > Mn > Zn > Pb > Cu > Cd. Morever, *T. zillii* seemed to accumulate most of the studied trace elements in their muscles at higher rates than *O. niloticus* which reflects its high affinity to heavy metals uptake more than the latter species. In addition to, these observations are mainly due to the different feeding habits and physiology in relation to the surrounding habitat, which reflects its high affinity to heavy metals uptake more than the latter species these results agree with those reported by Abdel-Baky et al. (1998). The relative order of heavy metals abundance can be summarized as follows: sediment > fish > water.

Fish may absorb dissolved elements and trace metals from its feeding diets and surrounding water leading to their accumulation in various tissues in significant amounts and exhibiting toxicological effects at target criteria (McCarthy and Shugart, 1990). Because most trace metals tend to accumulate in the different body organs, these metals are dangerous for fish and in turn they lead to serious problems in both humans and animals (Marzouk, 1994).

Siegel et al. (1994) recommended that further development of aquaculture in Ginka subbasin of Lake Manzalah or food-stuff agriculture on recently reclaimed lagoon bottom, or where irrigation waters come from Bahr El-Baqar Drain should be strictly limited until potentially toxic metals in the drain waters and sediments are removed and polluted input drastically reduced. This environmental assessment of heavy metals in aquaculture and agriculture development should extend to other waterbodies in the northern Nile Delta, particularly Edku Lagoon and Lake Mariut, where industrial metals-bearing wastes discharge into the water bodies.

Environmental pollution problems in El-Serw Fish Farm Inlet and Outlet canals were assessed by measuring the concentrations of some organochlorine pesticides in water, sediment and fish tissues of two tilapia species (*Tilapia zillii* and

Oreochromis niloticus). Table 3 illustrates the analysis of 13 organochlorine pesticides in water, sediment and fish collected from El-Serw Fish Farm. Organochlorine pesticide residues in both water and fish flesh showed undetectable concentrations. Sediment samples showed undetectable values except for para, para-Dichlorodiphenyldichloroethylene (*P, P*-DDE) recorded in one sample (0.034 μgg^{-1}) at Inlet.

Concentrations of 13 organchlorine pesticides in water, sediments and fish were present in non-detectable amounts. Consequently, the public is not at risk from fish consumption. These results are in accordance with Badawy and Wahaab (1997) who demonstrated that environmental pollution in Lake Manzalah with organchlorine pesticides in fish flesh didn't impose any threat on human health even if the public were totally dependent upon fish as a sole protein source. Although Badawy and Wahaab (1997) and Yamashita et al. (2000) found low amounts of organchlorine pesticides in fish flesh in Lake Manzalah, the present study didn't detect organchlorine pollution in fish flesh. This can by due to the feeding habits of farmed fish which feed on pollution free artificial diets in high amounts compared to feeding on polluted natural food, primarily algae, in Lake Manzalah.

4. Conclusion

Water quality parameters appeared to be within the acceptable ranges for tilapia culture (Bolivar et al. 2004). The values of most physico-chemical parameters are within the Fish Farm Standards according to Meade, (1989) and increased in Outlet. The concentrations of Fe in water were found higher than the permissible limits while concentrations of Cu, Zn, Mn, Pb and Cd within the permissible limits according to Meade, (1989). Also, the data indicated that, the order of occurrence of heavy metals in water: Fe > Mn > Zn > Pb > Cu > Cd, while in sediment was Fe > Mn > Zn > Cu > Pb > Cd.

The concentrations of Cd in Outlet sediment were higher than the permissible limits but the concentrations of Fe, Cu, Mn and Cd within the permissible limits according to OMOE, (1993).

Also, the accumulation trends of the trace elements in fish muscles of the two studied species *Tilapia zillii* and *Oreochromis niloticus* were found in the order of Fe > Mn > Zn > Pb > Cu > Cd. The value of Fe, Mn and Pb in fish muscles were higher than the permissible limits while the concentrations of Zn, Cu and Cd within the permissible limits according to FAO, (1992). Also, *T. zillii* seemed to accumulate most of the studied trace elements in its muscles higher than *O. niloticus*. The relative order of abundance elements can be summarized as follows: sediment > fish > water.

The organochlorine pesticides residues were not detected in water, sediment, and fishes and appeared only in one sample of sediment in very low concentration of the detected compounds and less than permissible levels according to Boyd, (1990). From previous discussion we can conclude that, most the concentrations level of different determined parameters of the agricultural drainage water were found in the permissible limits according to different standards. So, this water may be used as feeding source to rearing of the fish.

From previous discussion we can conclude that, most the concentrations level of different determined parameters of the agricultural drainage water was found in the permissible limits for fish farms according to different standards. So, this water may be used as feeding source to rearing of the fish.

Corresponding Author
D. G. Al-Afify
National Institute of Oceanography and Fisheries.Inland Water Branch, Egypt (NIOF)
afifydardeir@yahoo.com

Table 3. Concentrations of organochlorines in water, sediment and tissues (*Tilapia zillii* and *Oreochromis niloticus*) collected from El-Serw Fish Farm during 2007

Samples	Water (μgl^{-1})		Sediments (μgg^{-1})		Fish flesh (μgg^{-1})				Fish flesh (μgg^{-1})	Fish flesh (μgg^{-1})	Fish flesh (μgg^{-1})
					Inlet		Inlet				
Compoun	Inlet	Outlet	Inlet	Outlet	*O.n*	*O.n*	*O.n*	*O.n*	Inlet	Inlet	
Alpha-BHC	ND	ND	ND	ND	ND	ND	ND	ND	0.002	4.000	
Gamma-BHC	ND	ND	ND	ND	ND	ND	ND	ND	0.002	4.000	
Delta-BHC	ND	ND	ND	ND	ND	ND	ND	ND	0.003	4.000	
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	0.005	0.001	
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	0.004	0.003	
Heptachlor Epoxide	ND	ND	ND	ND	ND	ND	ND	ND	0.005	0.001	0.6
Gamma-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	0.002	0.010	
Endosulfan	ND	ND	ND	ND	ND	ND	ND	ND	0.003	-	
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	0.005	0.003	0.02
P,P-DDE	ND	ND	0.034	ND	ND	ND	ND	ND	0.003	-	2.2
Endrin	ND	ND	ND	ND	ND	ND	ND	ND	0.006	-	0.02
P,P-DDD	ND	ND	ND	ND	ND	ND	ND	ND	0.004	-	2
P,P-DDT	ND	ND	ND	ND	ND	ND	ND	ND	0.006	0.001	1

ND: Not Detected *T.z*: *Tilapia zillii* *O.n*: *Oreochromis niloticus*
LOD: limit Of Detection
Boyd, (1990): Safe level water (μgl^{-1})
Inlet: Agriculture drainage water which feeding source of El-Serw Fish Farm
Outlet: Drainage of El-Serw Fish Farm
NOAA, (1999): National Oceanic and Atmospheric Administration

5. References

1- Abdel-Baky, T. E.; Hagras, A. E.; Hassan, S. H. and Zyadah, M. A. (1998): Heavy metals concentration in some organs of *Oreochromis (Tilapia) Aureus* stein in Lake Manzalah, Egypt. J. Egypt. Ger. Soc. Zool., 25 (A), Comparative Physiology, 237 - 256.

2- Abdel-Gawad, S. S. E. (1993): Studies on macrobenthic invertebrates in El-Serw Fish Farm Region, M. Sc. Thesis, Fac. of Sci. Mansoura Univ. Egypt.

3- Aboul-Ezz, A. S.; Ibrahim, S. M. and Mohamed, F. A. S. (2002): Heavy metals concentration in different organs of some fish caught from the Mediterranean Sea. The Second International Conference and Exhibition for life and Environment. 3-5, April, 2001, 384 - 404.

4- Ali, M. H. H. and Abdel-Satar, A. M. (2005): studied of some heavy metals in water, sediment, fish and fish diets in some fish farms in El-Fayoum Province, Egypt. Egyptian Journal of Aquatic Research. 31(2): 261 - 273.

5- Allen-Gill, S. M. and Martynov, V. G., (1995). Heavy metals burdens in nine species of freshwater and anadromous fish from the Pechora River, Northern Russia. Sci. Total Environ., 160 - 161: 653 - 659.

6- Almazan, G. and Boyd, E. E., (1978): An evaluation of secchi disk visibility for estimating plankton density in fish ponds. Hydrobologia, 61: 205 – 208.

7- Al-Saad, H. T. (1995): Distribution and sources of hydrocarbons in Shatt Al-Arab estuary and NW Arabian Gulf. Ph. D. Thesis, University of Basrah.

8- AOAC, (1995): Official Methods of Analysis of AOAC International. 16th ed., Vol. 1 (Cunnif, P. Ed.), AOAC Int. Arlington, Virginia, USA.

9- APHA, American Public Health Association (1998): Standard Methods for the Examination for water and waste water. 4th Eddition, published by American Public Health Association. New York.

10- Biro, P., (1995). Management of pond ecosystems and trophic webs. Aquaculture 129: 373 - 386.
11- Bolivar, R; Jimenez, E. B. T. and Sugue, J. R. (2004). Effect of stocking sizes on the yield and survival of Nile tilapia (*Oreochromis niloticus* L.) on-Grown in ponds. 574 – 583.
12- Boyd, C. E. and Tucker, C. S., (1998). Pond aquaculture water quality management. Kluwer Academic Publishers, Boston, M. A, 700 pp.
13- Boyd, C. E., (1973). The chemical oxygen demand of waters and biological materials from ponds. Trans. Amer. Fish. Soc., 102: 606 - 611.
14- Boyd, C. E., (1982). Water quality management for pond fish culture. Elsevier Scientific Publishing Company, Amsterdam-Oxford-New York. 318 pp.
15- Boyd, C. E., (1990). Water Quality in Ponds for Aquaculture. Alabama Agriculture Experiment Station, Auburn University, Alabama, USA.
16- Boyd, C. E.; Romaire, R. P. and Johnston, E., (1978). Predicting early morning dissolved oxygen concentrations in chemical catfish ponds. Trans. Amer. Fish. Soc., 107: 484 – 492.
17- Bwala, R. L. and Omoregie, E., (2009). Organic enrichment of fish ponds: Application of Pig Dung vs. Tilapia Yield. Pakistan Journal of Nutrition, 8(9): 1373 – 1379.
18- Chaudhari, L. P., (2003). Sustainable use of natural resources for integrated aquaculture and agriculture: An Indian overview. Institute for sustainable Development and Research, Bombay, India, 187 – 195.
19- Chien, Y. H., (1992). Water quality requirements for marine shrimp culture, In: Wyban, J. (Ed.), Proceedings of the special session on shrimp. Farming, World Aquaculture Society, Baton Rouge, L. A, pp. 100 – 137.
20- Cole, G. A., (1979): Text book of limnology. 2nd Edition, St. Louis, Toronto, London, C.V. Mosby Company.
21- Daniels, H. V., Boyd, C. E., (1989). Chemical budgets for polyethylene-lined, brackishwater ponds. J. World Aquac. Soc. 20: 53 - 60.
22- Dewan, S., Hossain, M. S., Islam, M. S., Hossain, S. M. A., (1988). Exploration of pond fish production under village condition. Bangladesh J. Fish. 11: 101 – 104.
23- Dhawan, A, and Kaur, S., (2002). Pig Dung as pond manure: Effect on water quality, pond productivity and growth of carps in polyculture system. Naga, the ICLARM Quarterly, 25(1): January-March 2002: 11 – 14.
24- Diana, J. S., Szper, J. P.; Batterson, T. R.; Boyd, C. E. and Piedrahita, R. H., (1997). Water quality in ponds. In: Egna, H. S., Boyd, C. E. (Eds.), Dynamics of pond aquaculture. CRC Press, LLC, pp. 53 – 72.
25- ECDG, (2002): European Commission DG ENV. E3 Project ENV. E.3/ETU/0058. Heavy metals in waste. Final report.
26- Edwards, P., (1987). Sue of terrestrial vegetation and aquatic macrophytein aquaculture. In Microbial Ecology in Aquaculture, Vol. 14. ICLARM Conf. Proc., Manila, Philippines, pp. 311 – 315.
27- El-Deek, M. S., Okbak, M. A.; El-Attar, H. A. and El-Khatib, E., (1995). Mn, Fe, Cu and Zn in surficial sediments of Borollus Lake, Egypt. Mar. Res., 4: 7 – 13.
28- El-Sabrouti, M. A.; Abazza, K. M. and Mahmud, B. A., (1997). Organic matter, phosphorus and sulfur distribution in the surficial sediments of Manzalah Lagoon, Egypt. Fresenius Environ. Bull., 6: 403 – 409.
29- El-Sayed, M. A., Beltagy, A. I., Abou Nega, W. M. and Halim, Y., (1991). Role of humic substances in the accumulation of trace metals in bottom sediments. Bull. Natl. Inst. Oceangr. Fish. Egypt. 16: 239 – 254.
30- El-Wakeel, S. K., Saad, K., Wahby, S. D. and Saad, D., (1970). Bottom sediment of Lake Manzalah, Egypt. Journal of sedimentary petrology, 40: 780 – 496.
31- FAO, (1992): Committee for inland fisheries of Africa; Report of the third session of the Working party on pollution and fisheries. Accra, Ghana. 25 - 29 November 1991. FAO fisheries. Rep., No. 471. Rome, FAO. 1992. 43p.
32- Galbrand, C.; Lemieux, I. G.; Ghaly, A. E.; Cote, R. and Verma, M., (2008). Water quality assessment of a constructed wetland treating landfill leachate and industrial park runoff. American Journal of Environmental Sciences, 4(2): 111 – 120.
33- Golterman, H. L; Clymo, R. S. and Ohnstad, M. A. M., (1978). Methods forphysical & chemical analysis of fresh water-znded-(International Biological programme. Handbook; No 8) Blackwell. Scientific

Publications, pp. 215.
34- Jamu, D. M.; Lu, Z. and Piedrahita, R. H. (1999). Relationship between sechhi disc visibility and chlorophlla in aquaculture ponds. Aquaculture, 170: 205 – 214.
35- Khadr, A. M., (2005): Copper concentrations and phases in polluted surface sediments of Lake Edku, Egypt. Egyptian Journal of Aquatic Research, 31(2): 253 – 260.
36- Knud-Hansen, C. F. (1998). Pond fertilization: Ecological approach and practical application. Pond Dynamica/Aquaculture CRSP, Oregon State University, Corvallis, Oregon.
37- Koenings, J. P. and Edmundson, J. A., (1991). Secchi disk and photometer estimates of light regimes in Alaskan Lakes: effects of yellow color and turbidity. Limnol. Oceanogr., 36: 91 – 105.
38- Kouadia, L. and Trefry, J. H. (1987): Saline trace metal contamination in the Ivory Coast west Africa. Air, Water and Soil Pollution. 32: 145 - 154.
39- Kumar, M. S.; Binh, T. T.; Burgess, S. N. and Luu, L. T., (2005). Evaluation of optimal species ratio to maximize fish polyculture production. Journal of Applied Aquaculture, 17(1): 35 – 49.
40- Langis, R., Proulx, D., de la Noue, J., Couture, P., (1988). Effects of a Bacterial Biofilm on I Dhapnia Culture. Aquacult. Eng. 7: 21 - 38.
41- Li, L. and Yakupitiyage, L. L., (2003). A model for food nutrient dynamics of semi-intensive pond fish culture. Aquacultural Engineering, 27: 9 – 38.
42- Lotfy, I. M. H. (2001): Trace metals in waters, sediments and molluscan shells from El-Serw fish farm, Egypt. Delta Jornal of Science, 25: 140 – 157.
43- Magouz, F. I.; Mahmoud, S. A. and Abo-omer, Z. M. (1999): Effect of chemical fertilizer of the productivity of fish in poly-culture earthen ponds. Egyptian journal of Nutrition and Feeds. 2 (special issue): 743-751.
44- Marzouk, M. (1994): Fish and environment pollution. Vet. Med. J., 42: 51 – 52.
45- Mason, C. F. (2002): Biology of freshwater pollution. 4rd ed. Essex Univ. England. 387 pp.
46- McCarthy, J. F. and Shugart, L. R. (1990): Biomarkers of environmental contamination. Lewis Publishers. New York. 475pp.
47- Meade, J. W. (1989): Aquaculture management. New York: Van Nostrand Reinhold.
48- Milstein, A., Svirsky, F., (1996). Effect of fish species combinations on water chemistry and plankton composition in earthen fish ponds. Aquacult. Res. 27: 79 - 90.
49- Moriarty, D. J. W., (1997). The role of microorganisms in aquaculture ponds. Aquaculture 151: 333 - 349.
50- Mullin, J. B. and Riley, J. P. (1956): The spectrophotometric determination of nitrate in natural waters, with particular references to see water; Bull. Analytica, chemica ACTA 12: 479 - 480.
51- Neori, A., Krom, M. D., (1991). Nitrogen and phosphorus budgets in an intensive marine fishpond: the importance of microplankton. In: Cowey, C.V., Cho, C.Y. (Eds.), Nutritional strategies and aquaculture waste. pp. 223-230.
52- NOAA, (1999): National Oceanic and Atmospheric Administration) Screening quick reference tables (SquiRTs) http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html.
53- Nyandat, B., (2007). Analysis of feed and fertilizers for sustainable aquaculture development in Kenya. In M. R. Hasan, T. Hecht, S. S. De Silva and A. G. J. Tacon (eds). Study and analysis of feeds and fertilizers for sustainable aquaculture development. FAO Fisheries Technical Paper. No. 497. Rome, FAO., 423 – 436.
54- OMOE, (1993): Ontario Ministry of the Environment and Energy. 'Guidelines for the protection and management of aquatic sediment quality in Ontario August 1993, http://www.ene.gov.on.ca/envision/gp/B1-3.pdf. (ISBN 0.7729.9248-7). 32 pp.
55- Padmavathi, P. and Prasad, M. K. D., (2007). Studies on algal bloom disasters in carp culture ponds. Braz. J. Morphol. Sci, 24(2): 32 – 43.
56- Poxton, M. G., (1991). Water quality fluctuations and monitoring in intensive fish culture. In: De Pauw, N., Joyace, J. (Eds.), Aquaculture and the Environment. European Aquaculture Society Special Publication No. 16. Gent, Belgium, pp. 121 - 143.
57- Poxton, M. G., Allouse, S. B., (1987). Cyclical fluctuations of ammonia and nitrite nitrogen resulting from feeding of turbot, *Scophthalmus maximus* (L.), in recirculating systems. Aquacult. Eng. 6: 301 - 322.

58- Poxton, M. G., L1oyd, N.J., (1989). Fluctuations in ammonia production by eels (*Angulla anuilla* L.) as a result of feeding strategy. In: De Pauw, N., Jaspers, E., Ackefors, H., Wilkins, N. (Eds.), Aquaculture-a biotechnology in progress. Vol. 2. European Aquaculture Society, Bredene, Belgium, pp. 1125 - 1135.
59- Rahman, M. M. (2006a). Food web interactions and nutrients dynamics in poly culture ponds. Ph. D. Thesis, Wageningen University. The Netherlands. Pp. 157.
60- Rahman, M. M.; Verdegen, M. C. J.; Nagelkerke, L. A. J.; Wahab, M. A.; Milsten, A. and Verreth, J. A. J., (2006b). Growth, production and food preference of rohu *Labeo rohita* (H.) in monoculture and in polyculture with common carp cyprinus carpio (L.) under fed and non-fed ponds. In: Rahman, (2006). Ph. D. Thesis, Wageningen University. The Netherlands. Pp. 157.
61- Rahman, M. M.; Verdegen, M. C. J.; Nagelkerke, L. A. J.; Wahab, M. A.; Milsten, A. and Verreth, J. A. J., (2006c). Effects of common carp *Cyprinus carpio* (L.) addition and feeding on pond water quality and nutrient accumulation in rohu *Labeo rohita* (Hamilton) ponds. In: Rahman, (2006). Ph. D. Thesis, Wageningen University. The Netherlands. Pp. 157.
62- Rahman, M. M; Leopold, A. J. Nagelkerke, L. A. J.; Verdegem, M. C. J.; Abdul Wahab, M.; Johan, Verreth, J. A. J., (2008). Relationship among quality, food resources, fish diet and fish growth in polyculture ponds: A multivariate approach. Aquaculture, 275: 108 – 115.
63- Saad, M. A., (1983). Influence of pollution on Lake Mariut, Egypt. 1. Environmentalcharacteristics. RAPP.P.V-REUN. CIESM., 28: 207 –208.
64- Saeed, S. M.; and Shaker, I. M., (2008): Assessment of heavy metals pollution in water and sediments and their effect on *Oreochromis niloticus* in the Northern Delta Lakes, Egypt. 8th International Symposium on Tilapia in Aquaculture. 475 - 490.
65- Samaan, A. A. and Abdelmonem, M. A., (1986). Some physical features of the polluted basin and fish farm in Lake Mariute, Egypt. Bull. Inst. Oceanogr. Fish., Egypt, 12: 149 – 163.
66- Schroeder, G. L.; Alkon, A. and Laher, M., (1991). Nutrient flow in pond aquaculture. In: Brune, D. E., Tomasso, J. R. (Eds.), Aquaculture and water quality. World Aquaculture Society, Baton Rouge, pp. 489 - 505.
67- Siddiqui, A. Q., Al-Harbi, A. H., (1999). Nutrient budgets in tanks with different stocking densities of hybrid tilapia. Aquaculture, 170: 245 - 252.
68- Siegel, F. R.; Slaboda, M. L. and Stanley, D. J., (1994). Metal pollution loading, Manzalah Lagoon, Nile Delta, Egypt: implications of aquaculture. Environ. Geol., 23: 89 – 98.
69- Sin, A. W., (1987). The culture of tilapia (Sarotherodom mossambica) in secondary effluents of a pilot sewage treatment plant. Resources and Conservation, 13: 217 – 229.
70- SPSS Inc., (2001). SPSS Science Inc. 233 South Wacker Drive. Chicago, IL 60606-6307, USA.
71- Tang, Y. A., (1970). Evaluation of Balance between Fishes and Available Fish Foods in Multispecies Fish Culture Ponds in Taiwan. Trans. Amer. Fish. Soc. 4: 708 - 718.
72- Thakur, D. P.; Yi, Y.; Diana, J. S. and Lin, K., (2004). Effects of fertilization and feeding strategy on water quality, growth performance, nutrient utilization and economic return in Nile Tilapia (*Oreochromis niloticus*) ponds. pp.15 http://ag.arizona.edu/azaqua/ista/ista6/ista6web/pdf/529.pdf
73- Wafica, M. A., (1994). Enrichment of Fe, Mn, Cu, Zn, Pb and Cd in humic acid sediment cores, Lake Edku, Egypt. Arab Gulf J. SCI. Res., 12: 417 – 431.
74- Wudtisin, W. and Boyd, C. E. (2005). Determination of the phosphorus fertilization rate for bluegill ponds using regression analysis. Aquaculture Research, 36: 593 – 599.
75- Yi, Y., (1998). A bioenergetics growth model for Nile tilapia (*Oreochromis niloticus*) based on limiting nutrients and fish standing crop in fertilized ponds. Aquacultural Engineering, 18: 157 – 173.

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