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Impact of Poultry Slaughterhouse By-Product on the Aquatic Environment of Fish Ponds

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ABSTRACT

This study was conducted to investigate the effect of the raw by-product of poultry slaughterhouse on water quality, heavy metals accumulation, growth and flesh chemical composition of *Oreochromis niloticus* and *Clarias gariepinus* in earthen fishponds. The first treatment ponds (T1) received fresh poultry slaughterhouse by-product and died poultry which randomly assigned. The second treatment ponds (T2) (control) received commercial pelleted feed at a rate of 5% of fish body weight. Also, heavy metals and chemical properties of sediments were detected. The study revealed that, there were no significant differences in water temperature, alkalinity, hardness and water conductivity between the two treatments. Dissolved oxygen and water visibility were significantly higher in T2 than those of T1. Concentrations of nutrients; total ammonia, nitrite, nitrate, orthophosphate and chlorophyll "a" content in water as well as heavy metals load in muscle tissues of studied fish and sediments were high in T1 than those of T2 but still within the safe limits for aquaculture in fish ponds. Fish conditions of *O. niloticus* were not affected significantly, whereas those of *C. gariepinus* were changed in both treatment and control. The contents of moisture not changed significantly between the treatment and control. Crude protein was significantly lower in T1 than those of T2 for *C. gariepinus* but not affected significantly for *O. niloticus*. Contrarily, total lipids significantly increased in fish in T1 more than that of T2. No significant effect on ash content was observed for *O. niloticus* in both treatment and control; however, its content increase in T2 than that of T1 for *C. gariepinus*. In conclusion, poultry by-product ponds (T1) were more productive than feed ponds (T2) and its application can serve as organic fertilizer and feedstuff in fish ponds but further studies on the microbial load have to be conducted.

Keywords: slaughterhouse by-product, water quality, fish condition, sediment

INTRODUCTION

The current need to expand the world supply of food for the increasing human population has resulted in the development of intensive production of fish and other aquatic life. So, fish farming has virtually become the main hope of the growing Egyptian population government for achieving an optimistic animal-protein target to compensate the deficiency in meat production, in addition to fish as a component of the traditional Egyptian diet. Aquaculture production rose from 35.5 million tons in 2000 to 52.5 million tons in 2008 (FAO, 2010).

In Egypt, fish aquaculture is a prominent industrial activity and the fish production depends largely on fish farming which present about 62 % of the total fish production. The fish culture area is widely extended and the main cultured species are tilapia, mullets and catfish. However, fish production is hampered by high cost of aquaculture food (Saeed and El-Gammal, 2009). In fish culture, the cost of fish feed and inorganic fertilizers, contributing about 40–60% of the total input cost (Dhawan 1998). Reduction in feed costs makes some of poor fish growers to use some materials of low costs as poultry slaughterhouse by-product and died poultry in fish culture. Poultry processing in formal and informal abattoirs in Egypt produce tremendous quantities of by-product (meat, offal, blood, bones, etc.) (Abdeghany *et al*., 2005).

Poultry by-products, which are rendered by-products from the poultry processing industry, are produced in many parts of the world including the southeast Asia region which accounts for approximately one-quarter of the global poultry trade (FAO, 2009). Application of fresh, untreated poultry by-products of slaughterhouse and dead whole chickens to fish ponds is common in Asia (Prinsloo and Schoonbee, 1987) and this practice has given high yields but excessive amounts can cause killing of fish due to oxygen depletion in the water. It has high potential to be incorporated in the diet of carnivorous fish species due to its high protein contents, nutrient-rich and lower price compared to other fish feed materials.

Poultry by-product, made of heads, viscera and clean parts of carcass of slaughtered poultry (Shapawi *et al*., 2007) has great variability in their quality at the time of use as fish production inputs. Poultry by-products appear to be excellent protein and lipid sources containing 69% crude protein, 10-21% lipid and about 10% ash (Adewumi *et al*., 2011).

It is a common consensus that the feed material should supply good and healthy growth and economical development for fish. These sources may pose a potential health risk to handlers and consumers of such fish through the accumulation of heavy metals, pathogens and pesticides in the fish and, as a result, the possible transmission of diseases to man. Fish consumption is an important avenue for pathogens and heavy metals exposure to man (Christopher *et al*., 2009). In chicken-fish system, heavy metals contained in both chichen feed and manure are consumed by fish with the possible accumulation to high levels and the possibility of transfer of these metals to man (Nnaji *et al*., 2011).

There are many researches on nutritional quality of poultry by-product for fish diets (El-Sayed, 1998; Yang *et al*., 2006; Metwalli, 2008; Saoud, 2008; Giri *et al*., 2009 and Soltan, 2009); however, there is a lack of information on the utilization of fresh poultry by-product in fish pond as manure or as feed ingredient as well as its effect on aquatic environment.

So, the present study was conducted to evaluate the efficacy of poultry by-product as pond manure and as a feed ingredient in terms of water quality parametes, pond productivity (chlorophyll "a"), fish condition (condition factor, hepato-somatic index and length-weight relationship), proximate chemical composition (moisture, protein, lipid and fat content) and metals accumulation in flesh of *O. niloticus* and *C. garipienus* compered to commercial pelleted artificial feed. Pond sediments were also collected and analyzed chemically for some metals and chemical properties.

MATERIALS AND METHODS

Water and sediment samples were collected monthly from two private farms (each of five shallow ponds). The ponds were of the same area 1 feddan each with an approximately average depth of 1.2 m and located in Abou-Hammad, Sharkia Governorate. The first farm (treatment 1) used fresh poultry slaughterhouse by-product and died poultry (de-feathered) that were obtained from poultry farms and randomly assigned, whereas the second one (treatment 2) used commercial pelleted feed (25% protein) as feed for fish. The ponds of T1 and T2 were situated in the same region, receive its water supply from agriculture drainage water and stocked with Nile tilapia (*Oreochromis niloticus*) (47.3±2.1 g at a rate of 1 fish/m^2) and catfish (*Clarias gariepinus*) (92.2±5.1 g at a rate of 1 fish/10 m^2). The sampling period was extended for four months (May-August) during the culture season which extends from March to October 2010. Fish samples were collected when the ponds drained at the end of the season.

1- Sampling

Water samples were taken from different places at each site by a PVC tube column sampler at depth of half meter from the water surface. The samples at each site were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Sampling of bottom sediments (at the upper 10 cm) were carried out from 5 fish ponds (at multiple points) at each farm using Peterson grab as described in (Boyd and Tucker, 1992) and kept in cleaned plastic bags. The wet sediment samples were air dried, pulverized, and then combined within ponds and mixed to provide a homogeneous mixture for chemical analysis. Samples of *O. niloticus* fish with total mean lengths of 22.8 cm and 21.38 cm and total mean weighs of 207.60 g and 196.13 g for T1 and T2, respectively were collected. The total mean length and weight of *C. gariepinus* were 38.00 cm and 360.11 g and 34.31 cm and 354.55 g for fish collected from T1 and T2, respectively. Fishes used in estimation of the biological parameters, proximate analysis and metals residues.

2- Laboratory analysis

a) Water

Temperature and pH were measured with pH meter (Model 25, Fisher Scientific). Concentration of total alkalinity and total hardness (mg/l as $CaCO_3$) by titration. Electric conductivity (EC as mmohs) was determined using a salinity-conductivity meter (model, YSI EC 300). Dissolved oxygen (mg/l) was measured by using a digital oxygen meter (Model YSI 55). Total ammonia, nitrite, nitrate, orthophosphate (mg/l) and chlorophyll "a" content (µg/l) were estimated calorimetrically. Transparency (cm) was measured by using a Secchi Disc (SD) of 20 cm diameter. All measurements were conducted according to Boyd and Tucker (1992).

b) Fish

Metals concentration in muscle tissues were extracted by the method described in AOAC (1990). Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation) instrument was used to detect metals concentrations which were expressed as µg/g. dry wt. The proximate analysis of fish was achieved according to the standard methods of AOAC (1990) for moisture, protein, fat and ash content. The fish condition was assessed by calculating condition factor (K) and hepato-somatic index (HSI) according to Schreck and Moyle (1990). These parameters were calculated as: K = (Wt/L^3) x 100; where Wt is the total gutted weight of the fish (g), and L is the total length (cm); HSI = (WL/Wt) x 100; where WL is the weight of the liver (g).

c) Sediment

Sediment pH was measured with a glass electrode of a digital pH meter (Model 25, Fisher Scientific). Organic matter was measured as loss on ignition at 550°C for 3 h, while organic carbon (OC %) was calculated from organic matter (OM) data using the conventional conversion: OM=1.7×OC (Boyd, 1995). Free carbonate (% $CaCO_3$) was measured by neutralization of $CaCO_3$ with 0.5 N H_2SO_4. Inorganic N (NO_2-N & NO_3-N) was extracted with 2M KCl and analyzed by cadmium reduction method, while total nitrogen was measured by kjeldahl method. Total phosphorus (TP) was determined colorimetrically with vanadomolybdate method after ignition (at 450°C for 4h) and digestion with HNO_3. Inorganic phosphorus (IP) was extracted as total P without ignition, while organic phosphorus (OP) was calculated from the difference between TP and IP. Metals in sediment samples were extracted by HNO_3, H_2O_2 and HCl. Atomic absorption spectrophotometer instrument (Model Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK) was used to detect the heavy metals concentrations as µg/g dry weight. Analysis of all items followed the methods described in Page et al. (1982).

3- Statistical analysis

One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference of the concentration of different items that were studied with respect to feed kind. Significant differences are stated at $P<0.05$ (Bailey, 1981).

RESULTS AND DISCUSSION

Water Quality Parameters

Water quality parameters are presented in Table (1). Water temperature varied within a narrow range of 23.0-30.17 °C throughout the experimental period.

Application of fresh poultry by-product caused a significant reduction ($P<0.05$) of water pH in contrast to the significant increase in treatment 2 of pelleted feed. The pH did not vary much among treatments. It varied from 8.54 to 9.33 for the two treatments. The desirable pH range for most fish species is 7-9 (Boyd, 1998 and Barker *et al*., 2009).

Total alkalinity, total hardness and electric conductivity were not affected sharply by treatments in this study. The higher value of alkalinity was recorded in T1 (405.83 mg/l) and the lower one in T2 (352.45 mg/l). The increase in the total alkalinity in T1 occurred possibly due to the adequate

Table (1): ***Physical and chemical characteristics of water in earthen fish ponds fed with poultry by-product (T1) and commercial pelleted feed (T2)***

Parameter	Treatment 1		Treatment 2		Acceptable ranges in fish ponds
	Range	Mean±SE	Range	Mean±SE	
Temp (C°)	23.40-30.17	28.1^{a}±3.11	23.0-30.0	27.8^{a}±2.29	
pH	8.54-8.89	8.68^{b}±0.03	8.59-9.33	8.89^{a}±0.05	7-9
T. alkalinity*	275.0-535.0	405.83^{a}±46.29	236.4-421.3	352.45^{a}±39.12	50-300*
T. hardness*	290.0-320.0	305.0^{a}±5.27	226.0-301.0	288.0^{a}±7.97	
EC (mmohs)	0.90-2.41	1.73^{a}±0.27	1.33-1.65	1.52^{a}±0.12	
DO*	5-12.0	6.48^{b}±0.22	6.3-14.2	9.08^{a}±0.35	5-15*
T. NH_4-N*	0.6-3.0	1.34^{a}±0.34	0.8-1.2	1.0^{b}±0.06	0.2-2.0*
NO_2-N*	0.03-0.35	0.13^{a}±0.05	0.012-0.019	0.016^{b}±0.00	<0.3*
NO_3-N*	0.22-0.39	0.33^{a}±0.07	0.19-0.46	0.27^{b}±0.05	2.0-10*
PO_4-P*	0.03-0.12	0.07^{a}±0.01	ND	ND^{b}±0.00	0.01-0.2*
Chl "a"**	153.5-396.27	262.04^{a}± 41.66	173.04-249.91	119.89^{b}±15.47	
SD (cm)	7.0-11.0	8.2^{b}±0.67	10.0-15.0	13.30^{a}±1.17	

Superscript a and b notations denote significant (P≤0.05) differences between the same items (within rows).
The presented data is the average of four months. * mg/l and **µg/l. Acceptable ranges Boyd (1998).
ND: not detected.

supply of inorganic carbon to water after the microbial transformation of organic carbon sources added through these manures. A similar reverse trend of reduction of pH and increased total alkalinity was also observed by Chandra Das *et al*. (2005) after application of organic inputs. However, alkalinity was high in both treatments, indicating that pond waters were well buffered. A desirable range of alkalinity is 50-300 mg/L, but fish survive in waters up to 400 mg/L (Boyd, 1998 and Barker *et al*., 2009).

Water hardness increased in T1 with a total mean of (305.0 mg/l). The increases in the total hardness in T1 in the present study was possibly because of the addition of higher quantity of divalent salt (Ca, Mg and/or Fe) to water after mineralization of poultry inputs. In T2, only sediment was the source of such divalent salts, which explains the lower total hardness in this treatment. The concentration of ions that represented by electric conductivity was not significantly different between the two treatments (1.73 mmohs in T1 and 1.52 mmohs in T2).

Dissolved oxygen (DO) was affected significantly by treatments (P<0.05) where it was higher in T2 than that of T1. DO attained lower value (6.48 mg/l) in T1 and this may be attributed to the high rate of activity (DO consumption in respiration and decomposition of high load of organic matter represented by die-off of phytoplankton and poultry by-product by bacteria). On the other hand, the higher value (9.08 mg/l) of DO recorded in T2 may be attributed to the photosynthesis activity of phytoplankton and the decrease in organic matter. However, no oxygen depletions were noticed in the two treatments. It is clear that DO content at the two treatments lied within the limits (5.0 mg/l) that satisfy the needs of successful fish production as reported by Boyd (1998).

Application of poultry by-product significantly increased all the inorganic nutrients, namely total ammonia (NH_4-N), nitrite (NO_2-N), nitrate (NO_3-N) and orthophosphate (PO_4-P) content in the water. The levels of these nutrients in the two treatments were significantly ($P<0.05$) different from each other with higher values in T1. Significantly higher concentrations of the nutrients in T1 might have been principally due to the decomposition of poultry by-product which is rich in these nutrients. Possibly, poultry by-product which containing a good amount of protein (45-47% protein) mineralized faster, producing higher amount of ammonia, responsible for the increase of T. NH_4-N in T1. Ammonia (which is a principal nutrient for phytoplankton) is a major waste molecules resulting from consumption and breakdown of proteins. Further, the higher increase in nitrite and nitrate may be due to the presence of soil microbes in addition to those present in the water column. The lower phosphorus content in the two treatments, unlike ammonia, nitrite and nitrate may be attributed to the immobilization and adsorption of phosphorous molecules with the sediment particles as mentioned by Chandra Das *et al*. (2005).

Total ammonia and bicarbonate components are the final products from the bacterial decomposition of organic matter (Barker et al., 2009). The desirable ranges are 0.2-2.0 mg/l for total NH_4-N, <0.3 mg/l for NO_2-N and 0.2-10 mg/l for NO_3-N in fish ponds (Boyd, 1998). Further, the large quantity of proteinaceous feed used in culture systems also contributes to a considerable amount of the metabolites in the pond (Chiba, 1986).

Chlorophyll "a" in ponds constitutes important component of fish food and thus, acts as an index of trophic status of the water body (Boyd, 1998). Chlorophyll "a" concentration which is an indication for the primary productivity (phytoplankton) was low in T2 (average=119.89 µg/l) compared to T1 (average=262.04 µg/l). This result might be due to the availability of nutrients required for phytoplankton flourishing on account of poultry by-product application. Nutrients result from decomposition of poultry by-product can be used to support fish culture by their action as fertilizers that stimulate production of natural food organisms, such as phytoplankton and detritus. Tilapias can grow rapidly on such natural feeds alone since they can utilize plankton and detrital food organisms effectively. The low abundance of phytoplankton recorded in T2 might be because of the low nitrogen and phosphorus concentrations compared with those in T1. Increased nutrients in fish farms efficiently influence the pond water productivity as it supplies the plankton with essential nutrients needed for multiplication and growth of food organisms which are the natural food for planktivorous fish (Adewumi *et al*., 2011). Also, the decomposition of uneaten feed liberates inorganic nutrients such as ammonia and orthophosphate, led directly to increase primary productivity of pond water. The nutrient release would increase gradually due to decaying of solid uneaten feed. Results of this study comply with Chandra Das *et al*. (2005) observed that the application of organic inputs caused a reduction in pH and DO but increased PO_4-P, total alkalinity, hardness, total ammonia, nitrite and nitrate content.

Secchi disc readings was negatively affected by treatments ($P<0.05$). The average values of transparency were generally higher in T2 (13.30 cm), whereas T1 showed the lower Secchi disc readings (8.20 cm) (Table 1). Water secchi disc readings was lower in T1 than that in T2, which might have resulted from the dispersion of colloidal clay particles, and the suspended organic particles due to fish movement in pond and the abundance of phytoplankton. Water transparency decreases with the abundance of phytoplankton and increases with particle sedimentation on the pond bottom (Milstein et al. 2003). In general, water quality measurements in both treatments were suitable for growth and biological activity of tilapia and catfish.

Fish

Metals accumulation in fish muscle of *O. niloticus* and *C. gariepinus* in the two treatments is shown in Table (2). Fe (in tilapia and catfish), Zn and Pb (in catfish) and Cd (in tilapia) showed significant ($P<0.05$) difference between the two treatments. It was observed that, the concentrations of all studied metals (except Mn) in fish reared in T1 were higher than those reared in T2. This may be explained by the fact that some metals are used as additives in chicken feed and manures, especially Zn (Nnaji et al., 2011). The last authors also added

Table (2): ***Heavy metals concentrations (µg/g dry wt.) in muscles of O. niloticus and C. gariepinus reared in earthen fish ponds fed with poultry by-product (T1) and commercial pelleted feed (T2)***

Fish sp. / Metals	*O. niloticus* Treatment 1	*O. niloticus* Treatment 2	*C. gariepinus* Treatment 1	*C. gariepinus* Treatment 2	PL* (mg/d wet wt.)
Fe	$97.36^{a}\pm$ 15.22	$51.43^{b}\pm$ 10.74	$130.53^{a}\pm$ 16.74	$81.78^{b}\pm$ 11.74	43.0
Zn	$36.96^{a}\pm$ 4.81	$34.5^{a}\pm$ 6.93	$67.63^{a}\pm$ 11.06	$29.13^{b}\pm$ 4.13	60.0
Cu	$3.04^{a}\pm$ 0.19	$3.61^{a}\pm$ 0.21	$5.98^{a}\pm$ 1.01	$2.03^{b}\pm$ 0.13	3.0
Mn	$0.65^{a}\pm$ 0.12	$1.10^{a}\pm$ 0.10	$0.17^{b}\pm$ 0.16	$1.16^{a}\pm$ 0.11	2.0-9.0
Cd	$0.19^{a}\pm$ 0.014	$0.02^{b}\pm$ 0.00	$0.04^{a}\pm$ 0.00	$0.02^{a}\pm$ 0.00	0.10**
Pb	$0.26^{a}\pm$ 0.02	$0.23^{a}\pm$ 0.03	$0.16^{a}\pm$ 0.02	$0.02^{b}\pm$ 0.00	0.214
Total mean	138.46	90.89	204.51	114.14	

Data shown with different letters in rows are statistically different at P ≤ 0.05 level. *PL: Permissible limits (wet wt.) according to FAO/WHO (1999). **µg/g. To compare with PL in (wet wt.), multiply results of this study (dry wt.) by 5.

that, the integrated chichen-fish farming system cause accumulation of metals in water, fish and sediments which ensures that these metals may reach high levels in fish organs. Muscle tissues of *C. gariepinus* accumulate higher levels of most metals than *O. niloticus* and this may be related to the difference in feeding habits between the two species. The recommended daily intake for an adult human is 48, 60, 2.0-9.0, 3.0, 0.1 and 0.214 mg/day (except Cd µg/day) wet weight for Fe, Zn, Cu, Mn, Cd and Pb respectively according to FAO/WHO (1999). So, a normal daily diet including this fish species from both treatments poses no health risk to consumer.

As shown in Table (3), growth factor (b) and condition factor (k) of *O. niloticus* and *C. gariepinus* were close to 3 and > 1 in T1 and T2, respectively. On the other hand, hepato-somatic index (HSI) recorded high values (>2) for tilapia than catfish (>1) and a significant (P<0.05) difference was observed between the two treatments for K and HSI of catfish. The b, K and HSI values of the same species in two treatments provide an evidence that poultry by-product not adversely affect growth and well being of fish. The increase in fish condition in T1 than in T2 may be related to the non-digested feed, metabolic excretory products and residues resulting from microbial synthesis contain considerable quantities of nutrients for fish production (Fashakin et al., 2000). The wastes also serve as direct feed to fish in ponds.

The results of proximate analysis of fish muscle for moisture, protein, fat and ash are shown in Table (4). Application of poultry by-product had a significant effect on the proximate composition of the fish indicating that the availability of food could influence the composition. There is a high increase in fat content and a reduction in ash from the fish species in the present study across treatments. The present results comply with Giri et al.

(2009), who reported that the fish accumulated increasing quantities of lipids and decreasing levels of ash in their carcasses with increasing levels of dietary chicken viscera meal.

Sediment

Chemical properties of pond sediments are illustrated in Table (5). Sediment pH lies in the alkaline side and its values ranged between 6.99 in T1 to 7.91 in T2 and the mean pH values showed significant (P<0.05) difference between the two treatments. The pH showed an opposite trend with the percent of organic matter, that recorded the highest mean value

Table (3): Condition factor (K), hepato-somatic index (HSI), length-weight relationship of O. niloticus and C. gariepinus reared in earthen fish ponds fed with poultry by-product (T1) and commercial pelleted feed (T2)

Fish sp. / Item	*O. niloticus*		*C. gariepinus*	
	Treatment 1	Treatment 2	Treatment 1	Treatment 2
L-W relationship	Log W = - 1.3254 + 3.0051 Log L	Log W = - 1.6214 + 2.9812 Log L	Log W = -1.7866 + 2.9608 Log L	Log W = -1.9785+ 2.8831 Log L
Exponent "b"	3.0051	2.9012	2.9608	2.8831
Condition factor (k)	$1.73^{a} \pm 0.07$	$1.70^{a}b \pm 0.04$	$1.74^{a} \pm 0.03$	$1.63^{b} \pm 0.02$
HSI	$2.28^{a} \pm 0.17$	$2.08^{a} \pm 0.09$	$1.16^{b} \pm 0.11$	$1.41^{a} \pm 0.07$

Data shown with different letters in rows are statistically different at P ≤ 0.05 level.

Table (4): ***Flesh proximate chemical analyses of O. niloticus and C. gariepinus reared in earthen fish ponds fed with poultry by-product (T1) and commercial pelleted feed (T2).***

Fish sp. / *Item %	*O. niloticus*		*C. gariepinus*	
	Treatment 1	**Treatment 2**	**Treatment 1**	**Treatment 2**
Moisture	**80.78^{a}±1.55**	**81.45^{a}±2.11**	**81.05^{a}±2.17**	**80.16^{a}±3.14**
Crude protein	**84.89^{a}±6.17**	**88.22^{a}±4.55**	**72.98^{b}±5.23**	**80.35^{a}±7.11**
Total lipids	**9.51^{a}±2.01**	**5.75^{b}±1.11**	**21.51^{a}±4.23**	**13.22^{b}±2.31**
Ash	**5.56^{a}±0.45**	**5.94^{a}±0.61**	**5.52^{b}±0.33**	**6.37^{a}±1.02**

Data shown with different letters in rows are statistically different at P ≤ 0.05 level
****Dry weight basis.***

(8.57 %) in T1 and (4.27 %) in T2. This may be due to large inputs of organic matter which enrich increase of organic matter. Also, phytoplankton is considered a major source of organic matter in aquaculture ponds (Boyd, 1995). Concentrations of organic and total carbon increase in T1 (4.68 and 9.36 %) than in T2 (2.37 and 4.73 %) as organic matter increase. On the other hand, free carbonates and inorganic carbon in T2 exceeded that of in T1. Carbon accumulates in sediment as a result of fertilizer and feed inputs (Tepe and Boyd 2002). Aquaculture pond sediments may contain more than 3% organic carbon (Boyd, 1995). The optimum range of organic carbon in pond sediments is 1-3% (Banerjea, 1967). In T1, uneaten feed composed of soft tissues (meat, skin etc.), bones and dissolved materials settled on the bottom and decompose. Soft tissues composed of organic materials and containing most of the liquid components could be decomposed and gradually release dissolved nutrients. No significant (P>0.05) difference was observed in sediments of T1 and T2 for carbonate (as $CaCO_3$) and inorganic carbon.

NO_2-N concentration showed no differences between sediments of T1 and T2 (P>0.05); however NO_3-N concentration had greater values (P<0.05) in T1 than T2. In this study, the higher organic matter in the sediment resulted in higher nitrate concentration. Concerning the total nitrogen concentration, a significant difference (P<0.05) was observed between the two treatments with the highest mean (0.26 %) recorded in T1 and the lowest one (0.19 %) was observed in T2 sediment. This may be

Table (5): ***Sediments chemical analysis of earthen fish-ponds fed with poultry by-product (T1) and commercial pelleted feed (T2).***

Parameter	Treatment 1		Treatment 2	
	Range	Mean±SE	Range	Mean±SE
pH	**6.99-7.63**	**7.39^{b}±0.15**	**7.65-7.91**	**7.82^{a}±0.09**
Organic matter (%)	**7.41-9.79**	**8.57^{a}±0.59**	**3.8-5.14**	**4.27^{b}±0.44**
Organic carbon (%)	**3.74-5.76**	**4.68^{a}±0.33**	**2.00-2.98**	**2.37^{b}±0.31**
Carbonate (% $CaCO_3$)	**40.75-47.50**	**42.69^{a}±1.62**	**42.5-50.50**	**46.25^{a}±2.32**
Inorganic carbon (%)	**4.89-4.95**	**4.93^{a}±0.02**	**5.10-6.06**	**5.55^{a}±0.28**
Total carbon (%)	**7.48-11.52**	**9.36^{a}±0.66**	**3.99-5.96**	**4.73^{b}±0.62**
NO_2-N (µg/g)	**0.353-0.428**	**0.415^{a}±0.02**	**0.341-0.464**	**0.397^{a}±0.04**
NO_3-N (µg/g)	**21.57-25.93**	**23.95^{a}±1.27**	**10.76-19.35**	**14.82^{b}±2.49**
Total Nitrogen (%)	**0.19-0.30**	**0.26^{a}±0.04**	**0.17-0.24**	**0.19^{b}±0.02**
C/N ratio	**39.02-55.17**	**47.99^{a}±9.53**	**23.27-24.80**	**24.01^{b}±0.44**
Total P (µg/g)	**1044-1152**	**1107^{a}±211**	**588-1031**	**1023^{b}±200**
Inorganic P (µg/g)	**434.0-521.0**	**469.9^{a}±27.3**	**313.2-465.0**	**412.3^{a}±83.8**
Organic P (µg/g)	**609.3-719.0**	**647.3^{a}±77.3**	**124.0-571.9**	**344.0^{b}±63.0**

Superscript a and b notations denote significant ($P \leq 0.05$) differences between the same items (within rows).

as a result of increase of organic matter resulted from uneaten feed and phytoplankton die-off in T1.

The C/N ratio of organic matter has been widely used as index of the rate at which organic matter will decompose. A low C/N ratio (e.g. 10) favors more rapid and complete decomposition of soil organic matter than does for a high C/N ratio (e.g. 80) (Boyd, 1995). Wudtisin and Boyd (2006) mentioned that carbon to nitrogen (C/N) ratio usually was between 20 and 50 and this complies with values (24.01 in T2 to 47.99 in T1) recorded in the present study.

Concentrations of total phosphorus generally increased in sediments of T1 (total mean of 1107 µg/g dry wt.) compared to T2 (total mean of 1023 µg/g dry wt.). Most of the phosphorus in all pond sediments was organically bound and the proportion of organically bound to inorganically bound phosphorus increase as organic matter increase (total mean of 647 and 344 µg/g dry wt. in T1 & T2, respectively). Tepe and Boyd (2002) and Wudtisin and Boyd (2006) mentioned that organic phosphorus generally comprises a higher proportion of the total phosphorus in aquaculture pond sediment. They also added that phosphorus accumulates in sediment over time as a result of fertilizer and feed inputs. Moderate to high phosphorus concentrations in pond sediments favour greater fish production (Banerjea, 1967). Phosphorus accumulated in high amounts in bones, which may enriched the sediments. Bones may sink to the bottom, slowly putrefy and increase phosphorus and calcium content and could release nutrients in the water in T1.

Results of heavy metals in sediments are presented in (Table 6). The mean concentrations of metals differ between sediments from the two treatments and detected in the following order: Fe > Mn > Zn > Cu > Pb > Cd. The results showed that sediments of T1 which are characterized by having high values of organic matter content accumulate high levels of all studied metals, except for Mn and Pb compared to sediments of T2. The distributions of metals are associated mainly with the organic matter fraction of the sediment as found by Saeed and El-Gammal (2009), who also found a significant positive correlation between organic matter and each of Fe, Zn, Cu and Mn and no correlation with Pb.

The increases of Fe and Mn could be attributed to their increase in the earth's crust. Zinc and Cu accumulation could come from feed as recorded by Wudtisin and Boyd (2006). They also added that accumulations of Fe, Mn, Cu, and Zn could have occurred by precipitation with hydroxyl ions and carbonates under aerobic conditions. Schendel *et al*. (2004) proposed that, if the accumulation of heavy metals in the sediments is related to aquaculture activities, it must be accompanied by an accumulation of organic matter. Comparing the present results with the sediment quality guidelines, it is obvious that metals concentrations not exceeded these limits.

Table (6): Heavy metals concentrations (µg/g dry wt.) in sediments of earthen fish ponds fed with poultry by-product (T1) and commercial pelleted feed (T2).

Treat. / Metals	Treatment 1		Treatment 2		PL* (µg/g dry wt.)
	Range	Mean ± SE	Range	Mean ± SE	
Fe	8142.20-1532.41	10158.13[a]± 643.73	6242.19-7010.27	6741.33[b]±249.85	-
Zn	192.70-234.35	214.50[a]± 23.26	144.1-149.0	145.88[b]± 3.93	120-820
Cu	31.60-42.44	38.56[a]± 1.90	19.77-26.96	22.38[b]± 2.29	16-110
Mn	549.75-722.19	670.51[a]± 31.15	732.05-912.54	795.38[a]± 58.65	460-1110
Cd	0.06-0.58	0.43[a]± 0.09	ND	ND[b]±0.00	0.6-10.0
Pb	ND-3.46	1.72[a]± 0.32	1.89-4.22	2.71[a]± 0.56	31.0-250.0
Total mean		11083.85		7707.68	

Data shown with different letters in rows are statistically different at P ≤ 0.05 level. *PL: Permissible limits (wet wt.) according to Persaud et al., 1990. ND: Not detected

In conclusion, application of poultry by-product of slaughterhouse in fish ponds affect water quality, heavy metals accumulation in fish and sediment as well as fish condition and proximate chemical composition of muscle tissues of studied fish.

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تأثير مخلفات مجازر الدواجن الخام على البيئة المائية للأحواض السمكية

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أجريت هذه الدراسة لبحث مدى ملائمة مخلفات مجازر الدواجن الخام للاستزراع السمكي، ومقارنتها بالعلف الصناعى من حيث مدى تأثيرها على جودة المياه، وتراكم بعض العناصر مثل الحديد، الزنك،النحاس، المنجنيز، الكادميوم والرصاص فى عضلات الأسماك المستزرعة ورسوبيات الأحواض، إلى جانب بعض قياسات النمو والتركيب الكيميائى (رطوبة، بروتين، دهن ورماد) للأسماك، وأيضا تأثيرها على الخواص الكيميائية للرسوبيات .

تم اختيار مجموعتين من الأحواض الترابية، حيث تستخدم المجموعة الأولى (T1) مخلفات مجازر الدواجن الخام والدواجن النافقة منزوعة الريش، والمجموعة الثانية (T2) تستخدم العلف الصناعى. وقد أظهرت النتائج أن المعاملة (T1) غنية فى محتواها بالكائنات الأولية النباتية (الفيتوبلانكتون)، وقد تم تسجيل قيم عالية من معامل الحالة (K)، الدليل الكبدى (HSI)، ومعامل النمو (b) للأسماك. وكان تركيز بعض العناصر الثقيلة فى عضلات الأسماك أقل من النسب المسموح بها عالميا. وقد سجلت فروق ذات دلالة معنوية فى بعض القياسات الكيميائية للمياه والرسوبيات ولكنها فى حدود المسموح بها. وتوصى الدراسة بمزيد من الدراسات الميكروبيولوجية.