CHEMICAL CHARACTERISTICS OF FISH POND BOTTOM SEDIMENT AS A FUNCTION OF ORGANIC MATTER CONTENT

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Abstract

Some chemical properties of sediment and distribution of some metals (iron, zinc, copper, manganese, cadmium and lead) were studied in the upper 10 cm of 12 fish ponds from four farms situated in different regions in Egypt namely, Abbassa, Sahl El-Tina, Wadi El-Raiyan and Belkas (Sharkia, Port Saeed, Fayoum and Dakahlia Governorate, respectively) to evaluate their stability for fish culture. The study showed that the sediment pH lied in the alkaline side and negatively correlated with organic matter contents. The sediment concentrations of nutrients, major ions and metals showed positive correlation (P<0.05) with organic matter. Organic matter in sediments of Abbassa & Sahl El-Tina ponds increased compared to the other ponds. The different studied variables (nutrients, major ions and metals) were greater (P<0.05) in ponds of Abbassa & Sahl El-Tina than those in Wadi El-Raiyan & Belkas ponds. Salinity increased in accordance with salinity of the origin soil rather than pond organic matter. Total carbon, organic carbon and total nitrogen concentrations showed the same trend of nutrients and metals. Carbon: nitrogen ratio values differ (P<0.05) among ponds of the four farms tested. The results revealed that pond organic matter influence the chemical composition of pond sediments. Pond bottom management practices included drying of pond bottoms between crops, liming and periodic sediment removal have to be performed use by producers to maintain relatively good bottom quality especially in old ponds (Abbassa & Sahl El-Tina). Pond sediments of this study generally had favourable quality for use in aquaculture.

Key words: chemical characteristics, bottom sediment, fish ponds, organic matter.

INTRODUCTION

Fish aquaculture is a prominent industrial activity in Egypt. The fish production in Egypt depends largely on fish farming which present about 62 % of the total production. The fish culture area is widely extended and received water from the River Nile and irrigation drainage water. The main cultured species are tilapia, mullets and catfish.

Fish production, in aquaculture, is characterized by high loads of organic matter in the form of feed and/or organic fertilizers. As a result, organic matter accumulates on pond soils over time. Uneaten feed, senescent phytoplankton and fish feces are the principal sources of wastes from fish production activities (Wudtisin & Boyd 2006).

Whereas accumulation of inorganic solids physically interferes with fish harvest, accumulation of organic matter has an important effect on sediment composition (changing both physical and chemical characteristics) and acts as metal trap. Excessive amounts of organic matter in pond soils can result in deterioration of pond bottom condition and have negative effects on the survival and growth of aquatic animals (Boyd 1995). Also, these materials are rich in nitrogen and phosphorus that can readily be converted to forms available for algal growth, thus they have a potential to alter the trophic state of the pond water. Organic matter, phosphorous along with nitrogen compounds and metals are the most significant chemicals related to pollution from aquaculture facilities (Carbonell et al., 1998). They may reflect changes in the environmental conditions over a long period of time.

With the accumulation of organic matter, the oxygen demand increases and oxygen depletion in the sediments may occur. When anaerobic conditions develop in the pond bottom, fish growth is adversely affected because of the formation of toxic substances such as ammonia, nitrite and hydrogen sulfide (Tepe & Boyd 2002). Phytoplankton is considered the major source of organic matter in aquaculture ponds (Boyd 1995). Schroeder et al. (1991) found that as much as 50% of the algal standing crop settles on the sediment surface each day.

Soils are a major factor in pond aquaculture, because pond bottoms affect water quality and production. Concentrations of both nutrients and phytoplankton productivity in pond waters are related to pH and nutrient concentrations in soils (Boyd 1995). He also mentioned that, the composition of culture pond soils is altered by residues from feeds and fertilizers, settling of dead plankton, and accumulation of sediment and salts. Nguyena et al. (2005) declared that sediments provide a temporally integrated indication of the aquatic environment condition and act as a major reservoir for metals. The general opinion is that water quality deterioration is related to a decline in pond bottom quality as a result of sediment accumulation (Tepe & Boyd, 2002).

The accumulation of soft sediment in the deeper areas of ponds became problematic after 15-20 years of continuous culture (Wudtisin & Boyd, 2006). Accumulations of carbon, nitrogen and phosphorus in fish pond soils have been reported by several researchers (Fishar & Abdel-Regal, 1998, Ritvo et al., 2002, Tepe & Boyd, 2002, Thunjai et al., 2004, Wudtisin & Boyd 2006). Munsiri et al. (1996) reported a higher concentration of nutrients in soils of older shrimp ponds than in those of newer ones.

Sediment quality is a good indicator of pollution in water column, where it tends to concentrate the heavy metals and other organic pollutants. Metals concentrations in

sediments depend primarily upon the nature of the input sources. Metals may be released by redox-processes and move up to the water column leading to the exposure of aquatic organisms (Qari et al., 2005).

The present study was conducted to evaluate pond bottom quality in ponds used for fish production. The chemical properties (pH, nutrients, major ions and salinity) and distribution of some metals (Fe, Zn, Cu, Mn, Cd and Pb) in sediments from different aquaculture fish ponds in relation to soil texture and organic content were investigated.

MATERIALS AND METHODS

Sampling

Soil samples were collected from four fish farms, Abbassa, Sahl El-Tina, Wadi El-Raiyan and Belkas situated in regions namely, Sharkia, Port Saeed, Fayoum and Dakahlia Governorate, respectively. Sampling of bottom sediments (at the upper 10 cm) were carried out from 3 fish ponds (at multiple points) at each farm during the culture season of the year 2007 using Peterson grab as described in (Boyd & 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. Three sediment replicate samples from each site were combined.

Soil analysis

Soil pH was measured with a glass electrode of a digital pH meter (Model 25, Fisher Scientific) inserted into a 1:1 mixture of dry, pulverized soil and distilled water. Organic matter was measured as loss on ignition at 550°C for 3 h (Page et al., 1982), while organic carbon (OC %) was calculated from organic matter (OM) data using the conventional conversion: $OM=1.7 \times OC$ (Boyd, 1995). Free carbonate (% $CaCO_3$) was measured by neutralization of $CaCO_3$ with 0.5 N H_2SO_4 (Jackson, 1958).

Total phosphorus (TP) was determined colorimetrically with ascorbic acid reduction method after ignition (at 500°C for 4h) and digestion with H_2SO_4 and HNO_3 (APHA, 1985, Boyd & Tucker 1992). Inorganic phosphorus (IP) was extracted as total P without ignition, while organic phosphorus (OP) was calculated from the difference between TP and IP.

Electric conductivity (EC), total dissolved solids (TDS) and salinity were measured in (1:5) soil-distilled water extract using a salinity-conductivity meter (model, YSI EC 300). Soluble ions (HCO_3-alkalinity, Ca^{++}, Cl^- and SO_4-S) were measured in (1:5) soil-distilled water extract by the methods reported in APHA (1985) and Boyd & Tucker (1992). Total nitrogen was measured by kjeldahl method, while

inorganic N (NO_2-N & NO_3-N) was extracted with 2M KCl and analyzed by cadmium reduction method (Page et al., 1982).

Metals in sediment samples were extracted as described in Page et al. (1982). 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.

Statistical analysis

One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference of the concentration of different variables studied with respect to different farms. Regression analysis was also performed for the relationship among different variables. A probability at level of 0.05 or less was considered significant (Bailey, 1981).

RESULTS AND DISCUSSION

pH and organic matter

The sediment pH of the fish ponds is considered one of the most important factors made to determine bottom pond soil, characteristics, processes and productivity. In addition pH is essential in order to evaluate the expected solubility and availability of phosphates (Thomas, 1996).

Soils of the different farms are slightly basic and showed a slight variation in pH values. Sediment pH lies in the alkaline side and its values ranged between 7.67 in Wadi El-Raiyan ponds to 8.25 in Belkas ponds and the average pH values showed significant difference (P<0.05) among the four types of ponds (Table 1). The optimum pH range for aquaculture pond sediments is 7.5-8.0 because microbial activity is most rapid in this pH range (Boyd & Pipoppinyo 1994). Microbial decomposition of organic matter recycles nutrients and prevents accumulation of organic matter in pond bottoms. The water supply used to fill and maintain water levels in ponds contains high values of total alkalinity. Bases from the water supply may be the reason for increasing the pH of the sediment of the studied ponds. Also, age of ponds soil, organic matter and clay content of soil play a role in pH values of different ponds. It is possible that soils in the area where the young and sandy sediments (Belkas) were built had a naturally higher pH than the area for the other ponds.

Table 1. Overall means ± SE of pH, total alkalinity and organic matter in pond sediments of the studied farms.

Site \ Variables	pH	T. alkalinity mg/g	OM %
Abbassa	$7.84^b \pm 0.05$	$1.42^{ab} \pm 0.30$	5.88 ± 0.09^a
Sahl El-Tina	$7.74^b \pm 0.12$	$0.52^b \pm 0.04$	5.89 ± 0.19^a
Wadi El-Raiyan	$7.72^b \pm 0.06$	$1.65^a \pm 0.32$	3.71 ± 0.33^b
Belkas	$8.25^a \pm 0.04$	$0.55^b \pm 0.05$	1.37 ± 0.30^c

Means indicated by different letters differed (P<0.05) as determined by Duncan's multiple range test, vertical comparisons only. Each number is the average of three ponds.

Soil pH showed an opposite trend with the percent of organic matter, that recorded the highest values (5.88) in Abbassa and (5.89) in Sahl El-Tina farms, the lowest value (1.37) was recorded in Belkas farm. This may be due to large inputs of organic matter from feed and organic fertilizers which enrich the primary production at Abbassa and Sahl El-Tina farms which are older than Wadi El-Raiyan and Belkas farms.

Phytoplankton is considered the major source of organic matter in aquaculture ponds (Boyd 1995). Also, the decrease in soil pH of Abbassa and Sahl El-Tina ponds may be related to the high sediment clay content of these ponds. Ritvo et al. (2003) mentioned that soil pH decrease as clay content increase. They also added that the pH of the old ponds was lower than the pH of ponds that had been used for more than one production cycle. The same trend was reported by Fishar & Abdel-Regal (1998) in fish ponds at El-Fayoum Governorate.

The sediments showed variation in total alkalinity concentration with higher values in Abbassa and Wadi El-Raiyan and lower ones in Sahl El-Tina and Belkas as shown in table (1). Variation in alkalinity may be related to the bicarbonate content which comes with agriculture drainage water that fed these ponds.

Carbon and Nitrogen

Total carbon (TC) concentrations recorded no differences among the three farms, Abbassa, Sahl El-Tina and Wadi El-Raiyan, while the lowest value occurred in Belkas farm sediment (Table 2). Concentrations of total carbon ranged from 5.03% (Belkas ponds) to 9.01% (Wadi El-Raiyan ponds). Abbassa ponds were closer to Sahl El-Tina ponds with respect to total carbon concentration as they are of nearly the same organic matter content, whereas Belkas pond sediment showed the lowest value of organic matter content as it is a young ponds. Carbon accumulated in pond bottoms as a result of the deepening of sediment over time rather than by the development of a high carbon concentration in surface sediment Ritvo et al. (2002).

Table 2. Overall means ± SE of TC, OC, In C, carbonate, TN and C/N ratio in pond sediments of the studied farms.

Variables	Abbassa	Sahl El-Tina	Wadi El-Raiyan	Belkas
Total carbon (%)	$9.01^a\pm0.58$	$8.72^a\pm0.09$	$8.66^a\pm0.83$	$5.03^b\pm0.32$
Organic carbon (%)	$3.46^a\pm0.05$	$3.47^a\pm0.11$	$2.18^b\pm0.19$	$0.80^c\pm0.18$
Carbonate (% CaCO3)	$46.25^b\pm2.32$	$43.75^b\pm0.72$	$54^a\pm2.38$	$35.25^c\pm1.66$
Inorganic carbon (%)	$5.55^b\pm0.28$	$5.25^b\pm0.09$	$6.48^a\pm0.29$	$4.23^c\pm0.20$
Total Nitrogen (%)	$0.20^a\pm0.01$	$0.13^{bc}\pm0.01$	$0.18^{ab}\pm0.02$	$0.11^c\pm0.01$
C/N ratio	$17.61^b\pm1.06$	$26.03^a\pm3.42$	$12.01^b\pm3.06$	$7.19^b\pm4.49$

Abbreviations as in table 1, horizontal comparisons only.

Organic carbon (OC) concentration ranged from 0.80% to 3.47%. Abbassa and Sahl El-Tina ponds were similar and had a higher average organic carbon concentration (P<0.05) than Wadi El-Raiyan or Belkas ponds (Table 2). Belkas ponds had the lowest average organic carbon concentration. 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). Lower concentrations of organic carbon are unfavourable for the growth of benthic organisms that are important food for many fish species and higher concentrations favour anaerobic conditions at the sediment-water interface. Concentrations of organic carbon in old ponds of high organic matter content (Abbassa and Sahl El-Tina) were higher than in younger ponds (Wadi El-Raiyan and Belkas) of lower organic matter content. Carbon accumulates in sediment over time as a result of fertilizer and feed inputs (Tepe & Boyd 2002).

The carbonate (as $CaCO_3$) and inorganic carbon were the highest (P<0.05) in sediments of Wadi El-Raiyan. This may be related to the increase of fine sand sediments in this farm. There were no differences between Abbassa and Sahl El-Tina, while Belkas sediment had the lowest percentage (Table 2).

The total nitrogen (TN) concentration ranged from 0.11 to 0.20% (Table 2). A significant difference (P<0.05) occurred among the four farms with the highest value recorded in Abbassa, while the lowest one was observed in Belkas sediment. The high sediment clay content and age of Abbassa ponds play a role in increase of TN. Tepe & Boyd (2002) mentioned that TN increase as clay particles increase in sediments.

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). In the present study, the highest C/N ratios were recorded in pond sediments at Sahl El-Tina, while the lowest ones were recorded at Belkas followed by Wadi El-Raiyan pond sediments (Table, 2), which were near the favorable levels in relation to fish production. In this connection, Boyd (1995) reported that the most favorable C/N ratio in relation to fish production is 10-15. Wudtisin & Boyd (2006) mentioned that carbon to nitrogen (C/N) ratios usually were between 20 and 50. In the present study the carbon to nitrogen (C/N) ratios ranged between 7.19 and 26.03 which were greater than C/N ratios of 5 to 10 for research ponds used for channel catfish culture at Auburn, Alabama (Munsiri et al. 1995). Tilapia ponds in Thailand had an average total nitrogen concentration of 0.19% and a carbon: nitrogen ratio of 11 (Thunjai et al. 2004). The accumulation of organic matter in Sahl El-Tina sediments may be due to the high C/N ratio followed by Abbassa, Wadi El-Raiyan then Belkas farm.

Phosphorus

Total phosphorus concentration averaged 1047.04, 1124.79, 643.84 and 465.61 µg/g in Abbassa, Sahl El-Tina, Wadi El-Raiyan and Belkas pond sediments, respectively (Table 3). Concentrations of total phosphorus generally increased in Sahl El-Tina followed by Abbassa which characterized by high organic matter.

Table 3. Overall means ± SE of TP, IP and OP in pond sediments of the studied farms.

Variables	Abbassa	Sahl El-Tina	Wadi El-Raiyan	Belkas
TP	1047.04^a± 187.49	1124.79^a± 275.54	643.84^b± 38.62	465.61^b± 92.11
In P	412.22^a± 49.56	392.58^a± 46.22	308.89^a± 32.54	203.27^b± 27.60
OP	610.73^a± 293.34	732.22^a± 183.26	334.95^a± 9.13	262.34^a± 142.38

Abbreviations as in table 1, horizontal comparisons only.

It was assumed that most phosphorus in pond sediment was bound inorganically in iron, aluminum, and calcium phosphates (Boyd, 1995). This assumption was made because most terrestrial soils contain only 25-50% of phosphorus in organic combination (Sharpley, 2000). In this study, inorganic

phosphorus concentrations averaged between 203.27 and 412.22 µg/g, while the averages for organic phosphorus ranged between 262.34 and 732.22 µg/g (Table 3).

The average percentages of phosphorus were 52.93% and 47.07% in organic and inorganic combination, respectively. Thus, 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. Organic phosphorus generally comprises a higher proportion of the total phosphorus in aquaculture pond sediment (Tepe & Boyd 2002, Wudtisin & Boyd 2006). They also added that phosphorus accumulates in sediment over time as a result of fertilizer and feed inputs. Because of the near neutral pH, phosphorus availability from the sediment is relatively high.

Moderate to high phosphorus concentrations in pond sediments favour greater fish production (Banerjea 1967). Nevertheless, if pond sediments become saturated with phosphorus, they will no longer remove phosphorus from pond water.

Salinity

Sediment salinity as a measurement of EC, TDS and salinity in the sediment extracts ranged from 0.83 g/kg in Abbassa farm to 40.50 g/kg in Sahl El-Tina farm (Table 4). EC and TDS followed the same trend of salinity. The results showed that salinity varied related to the natural soil salinity in each farm rather than soil organic matter. The increase in sediment salinity in fish ponds of Sahl El-Tina may be related to the increase in sodium salts in these sediments.

Table 4. Overall means ± SE of EC, Salinity and TDS in pond sediments of the studied aquaculture farms.

Variables Site	Salinity g/kg	EC mmohs/cm	TDS g/kg
Abbassa	$0.83^b \pm 0.17$	$1.67^b \pm 0.34$	$1.07^b \pm 0.24$
Sahl El-Tina	$40.50^a \pm 12.00$	$69.32^a \pm 18.88$	$45.13^a \pm 12.29$
Wadi El-Raiyan	$1.67^b \pm 0.17$	$3.14^b \pm 0.15$	$2.49^b \pm 0.54$
Belkas	$3.83^b \pm 1.36$	$7.91^b \pm 2.36$	$5.16^b \pm 1.72$

Abbreviations as in table 1, vertical comparisons only.

Major ions and inorganic nitrogen

Table (5) shows that, Sahl El-Tina had the highest values of calcium. On the other hand, the concentration of calcium was statistically the same in Abbassa, Wadi El-Raiyan and Belkas farm. Chloride and sulfate ions followed the same trend of calcium ions. Concentrations of calcium, chloride and sulfate showed higher values in Sahl El-Tina ponds which had higher values of salinity than the other ponds (Table 5).

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This may be attributed to the fact that these ponds were constructed on soils with higher salinity that contains great values of calcium concentration.

Table 5. Overall means ± SE of major ions, Ca++, Cl-, SO4-S, NO2-N and NO3-N in pond sediments of the studied farms.

Variables / Site	Ca^{++} mg/g	Cl^- mg/g	SO_4-S mg/g	NO_2-N µg/g	NO_3-N µg/g
Abbassa	$0.41^b\pm$ 0.01	$0.63^b\pm$ 0.13	$2.78.49^b\pm$ 0.24	$0.40^a\pm$ 0.04	$14.82^a\pm$ 2.49
Sahl El-Tina	$7.72^a\pm$ 0.48	$39.08^a\pm$ 12.19	$135.82^a\pm$ 12.23	$0.43^a\pm$ 0.03	$13.33^a\pm$ 2.32
Wadi El-Raiyan	$0.50^b\pm$ 0.06	$0.97^b\pm$ 0.24	$9.22^b\pm$ 2.91	$0.38^a\pm$ 0.03	$9.02^{ab}\pm$ 0.90
Belkas	$1.30^b\pm$ 0.20	$3.60^b\pm$ 0.83	$13.83^b\pm$ 2.22	$0.36^a\pm$ 0.00	$5.65^b\pm$ 0.73

Abbreviations as in table 1, vertical comparisons only.

NO_2-N concentration showed no differences among sediments of the four farms (P>0.05) (Table 5). NO_3-N concentration did not differ between Abbassa and Sahl El-Tina sediments, however they had greater values than the other two farms (Table 5). In this study, the higher organic matter in the sediment results in higher nitrate concentration. It could explain the observed increase in NO_3-N over time in the present study.

An increase in soil nutrients concentrations was observed for all nutrient analyzed. The inputs of feed and fertilizers, biological retention by fish or other living organisms and nutrient retention by soil have different effects on the nutrients balance of ponds (Ritvo et al. 2002). In this study, the nutrients loading into the pond sediments increase as clayey texture sediment and the amount of feed and fertilizers applied to ponds (old pond increased). Ritvo et al. (2002) mentioned that eighty-three percent of the change in soil nitrate in shrimp ponds had due to the number of production cycles and clay percentage. Thus, it is possible that nitrogen originating from feed and fertilizers in the current study had been accumulated in the sediment over time. Munsiri et al. (1995) and Tepe & Boyd (2002) found that concentrations of several sediment quality variables increased over time.

The correlations between different variables in each farm and all ponds were illustrated in table (6). There was a negative correlation between sediment pH and organic matter content (r= -0.782, P<0.003). The association between soil Ca concentration and sediment carbonate content was observed in Abbassa, Sahl El-Tina

and Belkas sediments. The relationship between calcium concentration and salinity, salinity and sulfate is positive and significant. The relationships were positive between OM concentration and TP (r=0.643, P<0.024), OM and OP (r=0.848, P<0.004). A study of tilapia, carp and catfish pond sediments in Arkansas also revealed that total phosphorus concentrations increased as ponds organic matter increased (Tepe & Boyd 2002). The correlations were high between OM and TN (r=0.565, P<0.003) and OM and NO_3-N (r=0.793, P<0.002).Similar results were obtained by many authors (Ritvo et al. 2003, Tepe & Boyd 2002, Wudtisin & Boyd 2006).

Table 6. Correlation between different variables.

Farm / Items	Abbassa		Sahl El-Tina		Wadi El-Raiyan		Belkas		All ponds	
	r	p	r	p	r	p	r	p	r	p
pH & OM	-0.518	0.002	-0.512	0.031	-0.125	0.421	0.138	0.514	-0.782	0.003
pH & CO_3	0.654	0.004	0.676	0.021	-0.246	0.425	0.882	0.005	-0.612	0.010
Ca^{++} & CO_3	0.652	0.012	0.707	0.001	0.297	0.083	0.514	0.016	0.175	0.086
Salinity&Ca^{++}	0.250	0.103	0.937	0.000	0.750	0.001	0.976	0.000	0.933	0.000
Salinity&SO_4^{-}	0.218	0.075	0.931	0.000	0.855	0.000	0.907	0.000	0.930	0.000
OM & TP	0.913	0.000	0.988	0.000	0.909	0.000	0.937	0.000	0.643	0.024
OM & OP	0.862	0.002	0.997	0.000	0.995	0.000	0.935	0.000	0.848	0.004
OM & IP	0.484	0.151	0.621	0.039	0.978	0.001	0.283	0.083	0.487	0.252
OM&TN	0.650	0.002	0.878	0.001	0.982	0.000	0.745	0.039	0.565	0.003
OM&NO_3-N	0.841	0.002	0.948	0.000	0.832	0.000	0.511	0.061	0.793	0.002
OM & NO_2	0.799	0.032	0.542	0.017	0.793	0.011	0.244	0.074	0.315	0.122
TC&OC	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	0.882	0.000

Heavy metals

Heavy metals are accumulated in sediments, where they are incorporated in several biological and chemical cycles, affecting the water column and biota. On the other hand, chemical reactions can change the concentration of heavy metals in sediments and, as a consequence, in the overlying water (Qari et al., 2005).

The average concentrations of metals differ among sediments from the four types of aquaculture ponds and detected in the following order: Fe > Mn > Zn > Cu > Pb > Cd (Table 7). Sampling results showed that fish farms which are characterized by having high values of organic matter content accumulate high levels of metals. Fine sediments associated with high load of organic matter have a larger surface area, which allows heavy metals and other contaminants to be adsorbed easily Nguyena et al. (2005).

Table 7. Overall means (µg/g dry wt.) ± SE of studied metals in pond sediments of the studied farms.

Site \ Metal	Abbassa	Sahl El-Tina	Wadi El-Raiyan	Belkas
Fe	6741.33[ab]±249.85	9216.45[a]±1280.63	4388.94[ɒ]±1168.05	2129.16[c]±267.10
Zn	145.88[a]±1.57	104.07[b]±9.18	64.83[c]±7.29	46.61[c]±4.53
Cu	22.38[a]±2.29	26.52[a]±1.20	6.88[b]±0.59	10.56[b]±2.34
Mn	795.38[a]±58.65	756.81[a]±34.72	86.25[c]±11.76	233.12[b]±38.78
Cd	0.00[b]±0.00	0.03[b]±0.003	0.70[a]±0.10	0.75[a]±0.21
Pb	2.71[a]±0.76	0.00[b]±0.00	0.13[b]±0.13	0.00[b]±0.00
T. ave.	7707.68	10103.87	4547.72	2410.19

Abbreviations as in table 1, horizontal comparisons only.

On the other hand, the lowest abundance of metals was observed in Wadi El-Raiyan and Belkas farms which showed low levels of organic matter content, which means that the present level of organic matter content is limiting factor for the distribution of metals. The distributions of metals are associated mainly with the organic matter fraction of the sediment (Saeed & Shaker, 2008).

There was a significant positive correlation (P<0.05) between each of Fe, Zn, Cu and Mn and organic matter (Table 8). On the other hand Cd exhibit a negative correlation, while Pb showed no correlation (P>0.05) with organic matter content. The trace metals Cu and Zn show significant correlations with Mn and Fe as presented in table (8). This may reflect the variability of the fine sediment fraction in the bottom sediments as mentioned by Nguyena et al. (2005).

Table 8. Correlation between different metals and organic matter.

Variables	r	P	Variables	r	P
Fe&Zn	0.729	0.007	OM & Fe	0.875	0.000
Fe&Cu	0.750	0.005	OM & Zn	0.866	0.000
Fe&Mn	0.729	0.007	OM & Cu	0.738	0.006
Cu&Mn	0.962	0.000	OM & Mn	0.795	0.002
Zn&Mn	0.844	0.000	OM & Cd	-0.849	0.000
Fe&Cd	-0.804	0.002	OM & Pb	0.476	0.1177

r: correlation coefficient, P: level of significance (r is significant at P = or < 0.05).

The relations between OM and each of Fe, Zn, Cu, Mn, Cd, and Pb in sediments of the four farms were (r= 0.8581 in Sahl El-Tina, r= 0.9732 in Abbassa, r= 0.9963 in Belkas and r= 0.9118 in Wadi El-Raiyan) for Fe, (r= 0.4031 in Sahl El-Tina, r= 0.9170 in Abbassa, r= 0.3842 in Belkas and r= 0.9667 in Wadi El-Raiyan) for Zn, (r= 0.8802

in Sahl El-Tina, r= 0.3676 in Abbassa, r= 0.2686 in Belkas and r= 0.6389 in Wadi El-Raiyan) for Cu, (r= 0.8298 in Sahl El-Tina, r= 0.4011 in Abbassa, r= 0.2899 in Belkas and r= 0.8302 in Wadi El-Raiyan) for Mn, (r= 0.594 in Sahl El-Tina, r= 0.1011 in Abbassa, r= 0.1855 in Belkas and r= 0.1756 in Wadi El-Raiyan) for Cd and (r= 0.157 in Sahl El-Tina, r= 0.4004 in Abbassa, r= 0.2311 in Belkas and r= 0.7043 in Wadi El-Raiyan) for Pb.

The increases of Fe and Mn could be attributed to the dissolution of certain Fe and Mn oxides under reduced condition, which would turn these elements into a more soluble form in the extraction solution used to extract these elements in the present study. Zinc and Cu accumulation could came from feed as recorded by Wudtisin & 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. Accumulation of Fe and Mn can occur when soluble reduced Fe and Mn in the sediment diffuse upward and precipitate again near the oxic layer close to the soil water interface.

This explains the higher concentrations of heavy metals in sediments of these ponds. If the accumulation of heavy metals in the sediments is related to aquaculture activities, it must be accompanied by an accumulation of organic matter (Schendel et al. 2004).

Comparing the metals concentrations in this study (Abbassa and Sahl El-Tina) with those reported for other areas of the world, indicated that, the concentrations detected in this study (except Pb) were higher than those reported by (Wudtisin & Boyd 2006, Tepe & Boyd 2002) in fish farms. This could be attributed to the fact that sediments in this study were never removed. As with major cations, optimum concentrations of minor elements in pond sediments are not known (Thunjai et al. 2004).

CONCLUSION

The results reported above suggest that pond organic matter is an important factor determining the quality of bottom sediments. There were differences in sediment quality among sediments of the four pond farms of this study. Increase in the concentrations of C, N, P, NO_2-N, NO_3-N, Fe, Zn, Cu, Mn and Pb were detected in pond sediments of higher organic matter content than those of lower organic matter content. Ca^{++}, Cl^- and SO_4-S are mostly correlated with soil salinity than soil organic matter. Differences in major ions are thought to be significant in aquaculture ponds and this may be related to aquaculture inputs and sediment organic matter. Pond sediments of this study generally had favourable quality for use in aquaculture.

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الخصائص الكيميائية لراسب قاع أحواض المزارع السمكية بدلالة محتواها من المادة العضوية

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مركز البحوث الزراعية– المعمل المركزى لبحوث الثروة السمكية بالعباسة – قسم الليمنولوجى

أجريت هذه الدراسة على راسب قاع أحواض عدد من المزارع السمكية والتى تقع فى مناطق مختلفة من مصر وهى: مزرعة العباسة (محافظة الشرقية)، مزرعة سهل الطينة (محافظة بور سعيد)، مزرعة وادى الريان (محافظة الفيوم)، مزرعة بلقاس (محافظة الدقهلية) لتقييم جودة هذه المزارع للإستزراع السمكى، حيث تم دراسة الخصائص الكيميائية (درجة الأس الهيدروجينى، القلوية، المادة العضوية، الكربون العضوى وغير العضوى، النتروجين الكلى، الفوسفور الكلى، الفوسفور غير العضوى، الفوسفور العضوى، الملوحة، الكالسيوم، الكلوريد، الكبريتات، النيتريت، النترات) بالإضافة إلى تقدير متبقيات بعض العناصر الثقيلة (الحديد والزنك والنحاس والمنجنيز والكادميوم والرصاص). أوضحت الدراسة أن راسب قاع الأحواض تختلف فى التركيب الكيميائى والعناصر من منطقة لأخرى وقد كان محتوى الراسب من جميع المعايير الكيميائية التى تم قياسها أعلى تركيزا فى الراسب ذا المحتوى الأكبر من المادة العضوية (مزرعتي العباسة و سهل الطينة)، بينما سجل الراسب ذا المحتوى الأقل من المادة العضوية (مزرعة وادى الريان و بلقاس) القيم الأقل من هذه المعايير. كما كانت معاملات الارتباط بين معظم المعايير الكيميائية ومحتوى راسب قاع الأحواض من المادة العضوية طردية ومعنوية.