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THE IMPLICATIONS OF FISH AQUACULTURE ON THE QUALITY OF THE SEDIMENTS OF THE EARTHEN PONDS AT DELTA BREEDING STATION

Abbas, H. H.[1]; Esmat A. Nofal[1]; M. Abdel Meguid[2], Y. M. Ali[3]and Maha M. Ali[4]

1. Fac. of Agric., Banha University.
2. Environmental Research Institute- National Water Research Center.
3.Channel Maintenance Research Institute- National Water Research Center.
4.Central Laboratory for Environmental Quality Monitoring- National Water Research Center.

ABSTRACT

Egyptian aquaculture has been started with the use of traditional extensive and semi-intensive techniques. Rapid aquaculture development has occurred in recent years, after it had been identified as the best answer to reduce the increasing gap between supply and demand for fish. However, there is much concern about the increasing of the nutrient load and trace elements in sediment of earthen ponds due to the process of rearing fish of different sizes and ages**.** Based on this statement, the present study was conducted to investigate the characteristics of the bottom sediments of the earthen ponds at the Delta Breeding Station (DBS) and identifying problems raised from different activities especially that cause sediment pollution during rearing the fish, grass carp.

Results showed that the texture of the sediment in earthen pond was slightly similar. It ranged from sandy loam to loam. However, during rearing the grass carp in different sizes in the earthen ponds, the quality of the sediment has been widely changed after 3, 6 and 9 months from the stocking of fish. With increasing the period of stocking of fish in the earthen ponds, the values of pH have been statistically decreased, while the values of (EC), (HCO_3^-), (Ca^{2+}), (K^+), (Mg^{2+}), (Na^+), (Cl^-), (NO_2^-), (NO_3^-), (NH_4-H^+), (PO_4^{3+}), (SO_4^{2+}) ions and the heavy metals (Ba), (Cd), (Co), (Cr), (Cu), (Fe), (Mn), (Ni), (Pb), (V) and (Zn) have been statistically increased. Also the percentage of organic matter (O.M) increased. In addition, the sediments in earthen ponds which were stocked with the breeders of grass carp were characterized by having the higher values of anions, cations and heavy metals in the sediment more than the sediment of the earthen ponds which stocked with fingerlings of grass carp. This is mainly attributed to the feeding process.

Key words: fish aquaculture, sediments, earthen ponds.

INTRODUCTION

A large number of fish farms have been established in Egypt. Most of them are classified as semi-intensive brackish water farms (El Atfy and Abdel-Meguid, 2012). There are benefits from such aquacultures that include increases in farm productivity and profitability without any net increase in water consumption. However, there is much concern about an environmental hazard (Hektoen *et al*., 1995; Capone *et al*., 1996; Ali and Abdin, 2003; Jawad *et al*., 2004; Abdel-Meguid *et al*. 2005; Ali *et al*. 2006).

Previous studies have shown that intensive fish aquaculture can lead to higher proportion of organic materials and fertilizers such as ammonia, nitrate and phosphate compounds as well as the high proportion of heavy elements in the water and sediments (Madhav and Lin, 1996; Ali and Abdin, 2003; Bakry *et al*., 2004; Jawad *et al*., 2004; Ali *et al*., 2006; Tohamy *et al*., 2006 and El-Kholy, 2013). The presence of nutrients such as phosphates and nitrates can cause some inconvenience, such as the spread of various types of algae as well as the formation of a suitable environment for the growth and spread of many diseases that can cause the fish mortalities (Abdel-Meguid, 1998 and 1999).

Prowse (1971), Stanley (1974), ILACO (1983), and Bakry *et al*., (2004) stated that fertilization scheme as well as consumption of food and deposition of grass carp fecal matter may further enhance the phytoplankton and the filamentous algal productions through increasing the nutrients availability. Such nutrients may constrain water use in ponds by enhancing the process of eutrophication and increasing the inorganic and organic sedimentation and causing pollution to both water and sediment, as a result, anoxia may be established in the water column a few centimeters from the surface, and zooplanktons, benthos and fish particularly diminish (Boyd, 1971; Carter and Hestand, 1977; Von Donk *et al*., 1993; Schriver *et al*., 1995; Ali and Abdin, 2003; Ali *et al*., 2006).

In case of presence contaminants, the suspended sediment can mainly contribute to degraded water quality and cause adverse effects on critical habitats especially in the fish farms. Sediment suspended in the water column can reduce water clarity and increase light attenuation such that light penetration is below that needed to support healthy planktonic communities in ponds which are an important biological resource for fish feeding. For example, sediment can carry toxic contaminants, pathogens and phosphorous (P) that negatively affect the fish production. Excessive sedimentation also can degrade the vitality of benthic (bottom-dwelling) organisms and decrease their populations (CBP, 2006).

From this point of view, in polluted water, sediments are increasingly recognized as the most important sink of contaminants and as a reservoir and possible future source of pollutants. One from those pollutants are heavy metals which may adversely affect the soil ecosystem safety, not only fish production and water quality, but also the humen health (Adriano, 2001; Zhou *et al*., 2004). Heavy metals are elements that have metallic properties, atomic number over 20 (Nieboer and Richardson, 1980) and a density higher than 5.0 g/cm^3 (Sanita di Toppi and Gabbrielli, 1999). Heavy metals, even at trace concentration, can cause serious problems to all organisms and heavy metal bioaccumulation in the food chain can be highly dangerous (Sanita di Toppi and Gabbrielli, 1999).

The primary goal of the present study was to improve the fish productivity through reducing the pollutant loads within the sediment of the earthen ponds. To achieve this goal, to investigate the characteristics of the bottom sediments within the earthen pond in the Delta Breeding Station (DBS) and identifying problems raised from different activities in (DBS) especially that cause sediment pollution.

MATERIALS AND METHODS

Study area:

Delta Breeding Station (DBS) was established by Channel Maintenance Research Institute (CMRI) in 1981. (DBS) is locating at El-Kanater El-khairiea. It contains 11 rearing earthen ponds. These ponds have an average depth of 1.5 meter, all ponds are filled from the Nile River, and the dimension of the ponds and their arrangement are presented in Table 1 and Figure 1. The benefit of such ponds is to provide the Ministry of Water Resources and Irrigation (MWRI) with about ½ million of fingerlings of grass carp to be stocked in waterways for biological control against the aquatic weeds mainly the submerged aquatic weeds. The quality of the water supply from the Nile River is shown in Table 2. In the production ponds, fry are reared till the stocking weight (10-50 g). They feed on artificial pellet which contains fish–meal (20-30%), soya meal (15%) and sorghum (20%). The concentrations of heavy metals within this pellet are presented in Table (3). Later on, pond feeding is carried out with grass, maize and clover.

Table 1: Dimensions of the earthen ponds and their uses at the Delta Breeding Station (DBS)

Pond	Length (m)	Width (m)	pond area (m2)	Type of fish	Type of feed
D1	25.00	8.90	222.5	fingerlings	pellets
D2	25.00	8.80	220.0	fingerlings	pellets
D3	25.70	8.80	226.2	fingerlings	pellets
D4	26.20	8.80	230.5	fingerlings	pellets
D5	28.00	8.15	228.2	fingerlings	pellets
D6	19.35	7.70	149.5	fingerlings	pellets
D7	38.30	18.10	693.3	breeders	Green feed
D8	40.00	8.65	346.0	breeders	Green feed
D9	31.00	17.30	536.0	fingerlings	pellets
D10	71.00	17.30	1228.0	fingerlings	pellets
D11	71.00	17.30	1228.0	fingerlings	pellets

Table 2: Chemical properties of the water supply at the Delta Breeding Station (DBS)

Locations / property	Nile River El-Kanater El-khairiea
pH	8.04
EC (dSm^{-1})	0.43
Ca^{2+} ($mg\ L^{-1}$)	25
K^{+} ($mg\ L^{-1}$)	10.3
Mg^{2+} ($mg\ L^{-1}$)	17.4
Na^{+} ($mg\ L^{-1}$)	30.6
$NH_4\text{-}H^{+}$ ($mg\ L^{-1}$)	0.025
CO_3^{2-} ($mg\ L^{-1}$)	0
HCO_3^{-} ($mg\ L^{-1}$)	175.5
Cl^{-} ($mg\ L^{-1}$)	35.5
SO_4^{2-} ($mg\ L^{-1}$)	19.9
NO_3^{-} ($mg\ L^{-1}$)	0.12
PO_4^{3-} ($mg\ L^{-1}$)	0.15
Cu ($mg\ L^{-1}$)	0.006
Zn ($mg\ L^{-1}$)	0.019
Fe ($mg\ L^{-1}$)	0.126
Mn ($mg\ L^{-1}$)	0.105
Pb ($mg\ L^{-1}$)	0.017
Cd ($mg\ L^{-1}$)	0.002
Ni ($mg\ L^{-1}$)	0.005

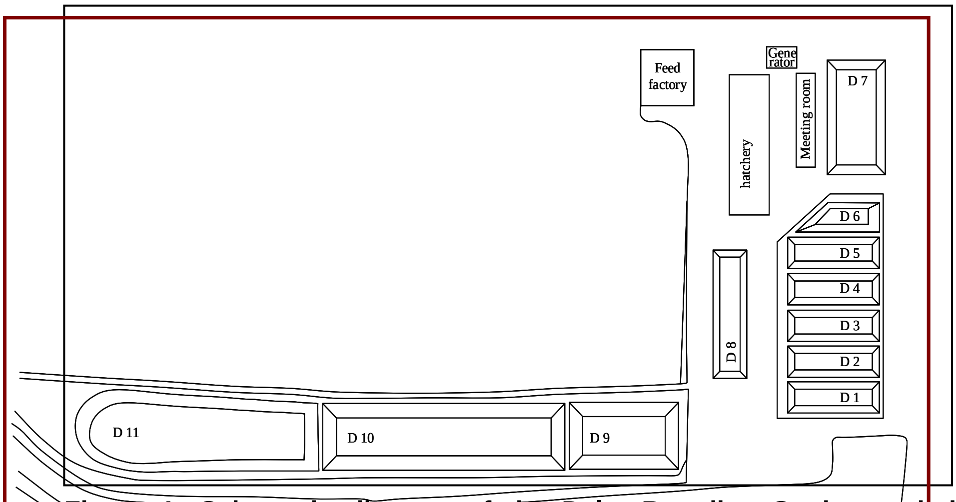

Figure 1: Schematic diagram of the Delta Breeding Station and the arrangement of its earthen ponds

Table 3: Concentrations of different heavy metals within the artificial pellets (mg kg^{-1})

Element	Concentration (mg kg^{-1})
Cu	6.94
Zn	10.48
Fe	155.1
Mn	38.93
pb	4.197
Cd	1.9
Ni	5.32

The experimental work:

An experimental work was conducted at the Delta Breeding Station. The sediment samples were collected from 11 earthen ponds in (DBS) as shown in Table 1 which describes the main characteristics of each pond and its use.

Surface sediments were chosen for this study as this layer controls the exchange of metals between sediments and water **(El Nemr *et al*., 2006).** The surface sediments were sampled randomly, carefully taken with sediment sampler from the top of sediment and collected as composite samples (3 grabs) from 11 earthen ponds after 3 , 6 months of stocking and after 9 months (after fish fingerlings harvesting).

The sediments were kept cool in an icebox during transportation to the laboratory.

Laboratory analyses:

The chemical parameters (pH, carbonate, bicarbonate, total alkalinity, electrical conductivity and O.M) were measured at 1:2 soil to water ratio extracts as soon as the samples reached the laboratory. For other analyses, the surface sediments were air-dried, homogenized using pestle and mortar, passed through a 2-mm mesh screen and stored in polyethylene bags. Percentage of organic matter was determined by Walkley-Black method as described by the Recommended by Chemical Soil Test Procedures, (1998).

Mechanical analysis was performed for sediment samples using hydrometer method according to (Gee and Bauder 1994).

For the determination of heavy metals, approximately 2g of each sample was digested with 15 ml of aqua-regia (1: 3 HCl: HNO_3) in a Teflon bomb for 2h at 120 ^oC. After cooling, the digested samples were filtered and kept in plastic bottles. Radojevic and Bashkin (1999) stated that aqua regia is adequate for extraction of total metals in soil sample and is widely used in most soil analysis laboratories. Heavy metals (aluminum, arsenic, barium, cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead, antimony, selenium, vanadium and zinc) and base cations (calcium, potassium, magnesium, sodium and ammonium) and base anions (nitrite, nitrate, phosphate, sulfate and chloride) were analyzed using standard methods of APHA (1998).

Statistical Analysis

The relationships among the values of both physical and chemical parameters within the sediment in earthen ponds after 3 , 6 month of stocking and after 9 month (after fish fingerling harvesting) were tested using Classify-Hierarchical Cluster Analysis (Dendrogram). To identify problems raised from different activities in the fish farm especially those cause sediment pollution, the physical and chemical parameters were evaluated after 3, 6 and 9 months from the fish stocking by using the statistical analysis (t test) "p=0.05".

RESULTS AND DISCUSSION

The present results revealed that the texture in earthen pond sediments was slightly similar as shown in Table 4. It ranged from sandy loam to loam. The textures of the sediments were sandy loam in ponds (D1, D2, D3, D4, D5, D6, D9, D10 and D11) while they were loamy in the ponds (D7 and D8). These textures of sediment meet the requirements of pond soil which include water-tight that is important in maintaining good water fertility and low turbidity that is principle for normal growth of fish and food organisms. (Yuan, 2012) mentioned that sandy soil has the problem of seepage, which can cause water current in pond and difficulty in maintaining fertility of water. Clay soil has the problem of high turbidity when there is wave in the pond due to the too fine soil particle.

Concerning the characteristics for the sediments, the results presented in Table 5, 6 and 7 showed that the sediments within the earthen ponds at (DBS) were widely different. These wide variations may depend on many factors which may include pollutants, either naturally present or added to the feed (components) before, during or after processing or regenerating within the feed by decomposition, water and its drainage system and nutrients in the effluent waters which are primarily derived from feed waste (fines/dust and feed not eaten by fish), and excreted and faecal wastes. Moreover, different fishes have different biological characteristics. Such characteristics change with the stage of their growth and development. So many biological characteristics of grass carp fry and fingerling are very different from their adults, e.g. diet composition, feeding feature, and environmental requirements etc. Therefore, it is very important to be aware about such characteristics for understanding the rearing technique.

Table 4: Texture of sediments in earthen ponds at Delta Breeding Station (DBS)

Ponds	Sand (%)	Silt (%)	Clay (%)	Textural class
D1	75.55	10.32	14.13	Sandy loam
D2	72.13	15.18	12.69	Sandy loam
D3	68.32	13.55	18.33	Sandy loam
D4	74.15	8.85	17.00	Sandy loam
D5	70.69	15.21	14.10	Sandy loam
D6	79.12	7.58	13.30	Sandy loam
D7	50.12	36.14	13.74	Loam
D8	48.87	38.32	12.81	Loam
D9	62.88	18.52	18.60	Sandy loam
D10	65.90	22.33	11.77	Sandy loam
D11	69.14	18.16	12.70	Sandy loam

Table 5: Chemical parameters in earthen pond sediment at Delta Breeding Station after three months from stocking of fish

Parameters	Con.	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
PH	-	7.29	7.38	7.58	7.97	7.43	7.49	7.51	7.3	7.45	8.11	7.46
CO_3^{2-}	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
HCO_3^-	mg kg^{-1}	103.7	122	91.5	115.9	109.8	103.7	122	115.9	122	128.1	146.4
EC	dS m^{-1}	0.593	0.586	0.459	0.573	0.563	0.555	0.576	0.58	0.59	0.575	0.711
Ca^{2+}	mg kg^{-1}	42	46	33.5	42	40	45	43	46	48	50	62
K^+	mg kg^{-1}	18.5	15.2	11.7	12.5	11.8	15	18	16	17	15	19
Mg^{2+}	mg kg^{-1}	18	18	13	17	14	13.2	15	14	14.5	13.5	15
Na^+	mg kg^{-1}	36	33.5	26	33	38	29	33	34	34	31	39
Cl^-	mg kg^{-1}	88.8	78.1	60.4	81.7	85.2	80	81.7	88	81.7	71.5	99.4
NO_2^-	mg kg^{-1}	0.24	0.23	0.23	0.32	0.45	0.44	0.28	0.27	0.23	0.21	0.25
NO_3^-	mg kg^{-1}	7.5	12.4	12.5	14.5	13.9	14.5	12.4	9.7	7.7	7.9	11.2
NH_4-H^+	mg kg^{-1}	5.5	6.8	7.6	8.7	9.5	10.5	8.8	8.4	6.6	7.2	10.9
PO_4^{3-}	mg kg^{-1}	3.5	3.8	4.2	5.8	7.1	7.9	6.9	7.5	6.8	6.9	9.9
SO_4^{2-}	mg kg^{-1}	68.5	62.5	47.5	51	44	50.5	47.5	47	58.5	60	65
Al	mg kg^{-1}	58420	51440	42330	46900	55240	46430	58080	61250	59980	48720	52490
As	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ba	mg kg^{-1}	336	247	410	401	456	408	450	470	438	380	384
Cd	mg kg^{-1}	3	4	3	2	4	3	6	8	5	7	8
Co	mg kg^{-1}	27	24	21	23	27	22	58	75	27	23	15
Cr	mg kg^{-1}	98	100	90	97	117	96	178	215	122	102	95
Cu	mg kg^{-1}	158	195	122	116	179	143	203	151	187	121	130
Fe	mg kg^{-1}	56880	53000	44640	48560	56360	45400	58870	57870	50750	47910	40040
Mn	mg kg^{-1}	439	440	453	692	519	527	640	700	632	693	633
Mo	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ni	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Pb	mg kg^{-1}	14	17	11	37	16	14	22	30	13	15	8
Sb	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Se	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
V	mg kg^{-1}	401	486	378	581	502	429	1619	1634	554	485	582
Zn	mg kg^{-1}	157	166	124	140	142	116	475	478	120	115	108
O.M	g kg^{-1}	16.9	20.1	16.9	16.9	20.1	13.2	16.9	22.1	16.9	22.1	32.1

Table 6: Chemical parameters in earthen pond sediment at Delta Breeding Station after six months from stocking of fish

Parameters	Con.	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
PH	-	7.4	7.5	7.4	7.6	6.8	7.1	7.3	7.2	7.3	7.21	7.01
CO_3^{2-}	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
HCO_3^-	mg kg^{-1}	122	128.1	152.5	122	134.2	109.8	134.2	140.3	122	128.1	152.5
EC	dS m^{-1}	0.695	0.706	0.693	0.606	0.655	0.601	0.66	0.695	0.626	0.601	0.855
Ca^{2+}	mg kg^{-1}	46	51	40	42	43	47	48	49	49	50	65
K^+	mg kg^{-1}	22	21	24	15	14	16	20	19	17.5	16	27
Mg^{2+}	mg kg^{-1}	21.5	21	21	18	18	14.7	18	20	15.5	14	22
Na^+	mg kg^{-1}	44	39	47	35	43	33	38	41	36	34	48
Cl^-	mg kg^{-1}	98	99.5	88.7	88	96	88.7	95.8	106.5	88.7	77.6	133.1
NO_2^-	mg kg^{-1}	0.27	0.27	0.28	0.25	0.28	0.28	0.32	0.34	0.35	0.31	0.31
NO_3^-	mg kg^{-1}	8.5	13.4	14.8	15.5	15.6	16.5	16.5	12.2	11.9	8.1	15.6
NH_4-H^+	mg kg^{-1}	7.1	9.5	9.6	10.4	12.5	11.1	9.9	10.5	9.3	8.5	12.5
PO_4^{3-}	mg kg^{-1}	4.9	7.7	7.5	6.2	9.8	8.2	7.7	8.8	7.9	7.2	11.1
SO_4^{2-}	mg kg^{-1}	87	78	67	52	47	54	54	52	60	63	76
Al	mg kg^{-1}	49240	46110	45390	41220	47830	44530	57750	61560	54350	56790	52750
As	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ba	mg kg^{-1}	379	374	441	458	363	428	470	470	522	536	507
Cd	mg kg^{-1}	5	5	5	6	5	5	5	5	6	8	11
Co	mg kg^{-1}	37	39	37	34	57	37	73	83	31	44	41
Cr	mg kg^{-1}	106	109	108	90	127	94	260	390	119	114	122
Cu	mg kg^{-1}	200	219	159	184	187	150	210	143	142	272	312
Fe	mg kg^{-1}	54830	56560	54420	48680	55600	54120	57210	62230	61450	65700	67250
Mn	mg kg^{-1}	578	655	557	573	530	635	661	694	652	955	1170
Mo	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ni	mg kg^{-1}	89	83	85	72	97	84	76	88	86	89	94
Pb	mg kg^{-1}	21	32	35	44	29	27	43	55	41	38	49
Sb	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Se	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
V	mg kg^{-1}	422	485	401	585	508	433	1639	1657	585	492	612
Zn	mg kg^{-1}	243	261	311	275	273	335	522	511	261	676	825
O.M	g kg^{-1}	20.1	22.3	27.5	22.1	24.5	16.9	20.1	27.5	28.5	26.9	40.2

The Hierarchical Cluster Analysis Figure 2 indicates that the sediments of the earthen ponds, after 3 months from the stocking of the grass carp could be clustered into two main groups basing on the parameters of sediment in each pond:

The first group contained the earthen ponds (D7 and D8) which were stocked with breeders of grass carp. The sediments in those ponds revealed the greater values. The second group was divided into two subgroups; the first one contained the sediments of the earthen ponds (D1, D2 & D5) and the second is sediments of earthen pond (D9). Those earthen ponds were also stocked with fingerlings of grass carp and their sediment contents revealed moderate total content of parameters especially trace metals. Concerning the other subgroup which was stocked with the fingerlings of grass carp, it revealed the smallest physico-chemical values. This group was divided into two subgroups. The first group contained the earthen pond (D11) while the second group contained the earthen ponds (D4), (D10), (D6) and (D3) as shown in Figure 2.

Table (7) Chemical parameters in earthen pond sediment at Delta Breeding Station after nine months from stocking of fish

Parameters	Con.	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
PH	-	6.1	6.82	6.83	6.48	6.79	6.67	6.5	6.79	7.16	6.5	6.79
CO_3^{2-}	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
HCO_3^-	mg kg^{-1}	152.5	134.2	152.5	134.2	152.5	115.9	134.2	146.4	134.2	152.7	158.6
EC	dS m^{-1}	0.84	0.727	0.697	0.703	0.875	0.613	0.757	0.788	0.752	0.705	0.926
Ca^{2+}	mg kg^{-1}	55	52	40	45	51	48	52	54	55	53	68
K^+	mg kg^{-1}	29	22	24.5	19	26	15.5	23	27	21	23	29
Mg^{2+}	mg kg^{-1}	27	21.5	21.2	21	27	15.2	22	23	19.5	18	27
Na^+	mg kg^{-1}	48	43	48	45	57	35	42	44	45	41	50
Cl^-	mg kg^{-1}	116	103.1	88.7	103.1	133.1	88.7	121	133.1	106.5	88.8	146.2
NO_2^-	mg kg^{-1}	0.32	0.34	0.32	0.3	0.33	0.34	0.37	0.4	0.39	0.38	0.38
NO_3^-	mg kg^{-1}	15.8	12.5	14.9	15.9	17.1	15.2	20.2	13.5	17.5	10.5	15.9
NH_4-H^+	mg kg^{-1}	10.2	8.4	9.2	11	14.6	10.2	12.9	12.1	12.1	9.8	13
PO_4^{3-}	mg kg^{-1}	7.9	6.4	7.6	7.5	13.1	8.3	10.2	10.5	9.1	8.7	11.5
SO_4^{2-}	mg kg^{-1}	99	82	69	65	82	56	58	53	80	73	88
Al	mg kg^{-1}	49160	52550	46090	44040	48640	46420	57840	61990	58370	50900	53700
As	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ba	mg kg^{-1}	440	470	510	590	540	670	440	490	540	547	600
Cd	mg kg^{-1}	9	10	7	7	8	6	9	10	11	15	12
Co	mg kg^{-1}	50	38	40	37	59	35	75	81	42	47	39
Cr	mg kg^{-1}	110	105	116	99	122	96	378	415	125	110	120
Cu	mg kg^{-1}	254	205	158	196	196	160	355	396	150	333	355
Fe	mg kg^{-1}	58240	54610	55330	56710	58680	60870	80400	81160	57609	67950	68890
Mn	mg kg^{-1}	640	630	660	700	620	740	928	1282	730	990	1200
Mo	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Ni	mg kg^{-1}	98	92	101	98	106	108	109	103	111	112	101
Pb	mg kg^{-1}	26	48	34	46	34	31	47	57	52	43	53
Sb	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
Se	mg kg^{-1}	0	0	0	0	0	0	0	0	0	0	0
V	mg kg^{-1}	429	503	414	603	515	445	1680	1705	599	485	605
Zn	mg kg^{-1}	247	294	313	371	268	407	585	595	319	701	753
O.M	g kg^{-1}	26.9	27.5	29.5	28.5	42.5	26.9	29.5	31.5	32.2	42.7	50.2

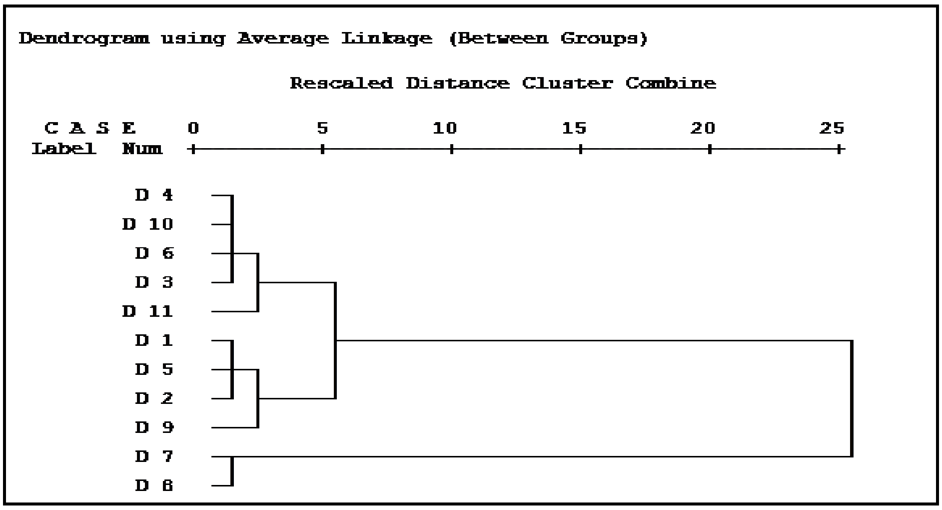

Figure 2: Hierarchical Cluster Analysis showing the linkage between different earthen ponds basing on the chemical parameters of the sediments after three months from the stocking of the fish

After 6 months from stocking the ponds with the fish of grass carp, the Hierarchical Cluster Analysis (Figure, 4) indicated that the quality of the sediments could be clustered into two main groups:

The first group contained the earthen ponds (D7 & D8) which were stocked with breeders of grass carp. The sediment of those earthen ponds revealed the greater physico-chemical values. Concerning the other group, it was divided into two subgroups. The first subgroup contained the earthen ponds D9, D10 and D11 which revealed moderate total content of parameters especially trace metals. The second subgroup was divided into two sub-sub groups, the first one contained the earthen pond (D4) while, the second group contained the earthen ponds (D3), (D6), (D2) (D1) and (D5) in which, the sediments had the smallest physico-chemical values, as shown in Figure 3.

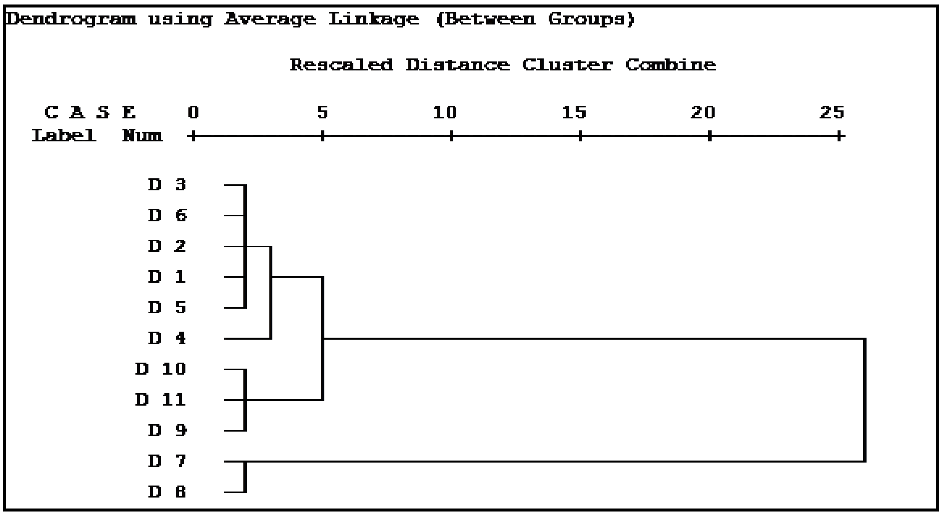

Figure 3: Hierarchical Cluster Analysis showing the linkage between different earthen ponds basing on the chemical parameters of the sediment after sex months from the stocking of the fish

After nine months from stocking the earthen ponds with the grass carp, the Hierarchical Cluster Analysis (Figure, 4) indicated that the sediments within the earthen ponds could be clustered into two main groups: The first group contained the earthen ponds (D7 & D8) which were stocked with breeders of grass carp. There earthen ponds revealed the greater chemical values. Concerning the second group it was divided into two subgroups. The first subgroup contained (D2), (D11) and (D9). These earthen ponds were stocked with fingerlings of grass carp and their sediments revealed moderate values of physico-chemical parameters especially trace metals. The second subgroup contained the earthen ponds (D1), (D5), (D10), (D6), (D3) and (D4). The sediments of this group was characterized by the smallest chemical values as compared with the other groups as shown in Figure 4.

Based on the cluster groups, the present study indicated that it is impossible to distinguish a general pattern or even similarity among the sediments within the earthen ponds. But, it is clear that the sediments in earthen ponds which were stocked by the breeders of grass carp are usually characterized by higher values of chemical parameters more than the sediments of the earthen ponds which were stocked with fingerlings of grass carp. This is properly due to the feeding processes (uneaten, decaying food and food consumption). **Yuan, (2012)** stated that the feeding habit of fish induces accumulation of waste at pond bottom, which causes heterotrophic bacteria breeding and leads to hypoxia (lack of dissolved oxygen), nitrite and nitrogen enrich. Oxygen deficiency causes pathogenic bacteria (e.g. vibrio) breeding and decreases cultured fish immunity ability; in that case, it is easy to happen disease. Sediment is seedbed of many pathogenic bacteria, remove excess slit at bottom, or introduce beneficial microorganisms to decompose waste.

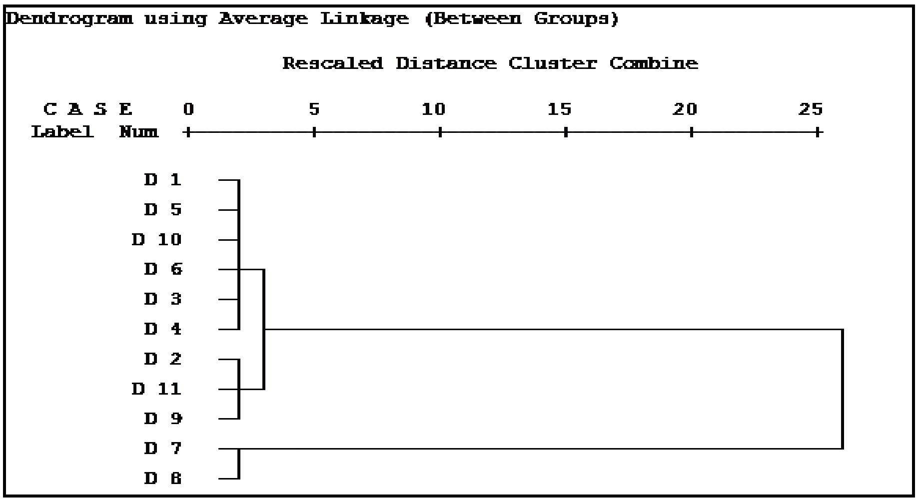

Figure 4: Hierarchical Cluster Analysis showing the linkage between different earthen ponds basing on the chemical parameters of the sediment after nine months from the stocking of the fish

The ponds which were used for rearing the fry were fertilized for proliferation of natural feed organisms and then were provided with supplemental artificial feeds at fingerlings stages, all grass carp feed on the same type of food with diet composition containing fish-meal (20-30%), soya meal (15%) and sorghum (20%), minerals and heavy metals as shown in Table 3 which are essential elements for fish body composition. So, the Hierarchical Cluster Analysis showed that sediments in earthen ponds that were used for rearing fry and fingerlings of grass carp were quite similar due to the similar structure of feeding, but, when the diet composition (clover) changes as fish grow (breeder) the quality of the sediments dramatically change.

To obtain more reliable information about the sediment quality in the earthen ponds at (DBS) after 3, 6 and 9 months from the stocking of fish and to identify problems raised from different activities in the fish farm especially that cause sediment pollution, the physical and chemical parameters were evaluated after 3, 6 and 9 months from the fish stocking by using the statistical analysis (t test). The results presented in Table 8 showed that sediment absorbed heavy metals and some nutrients from different inputs and it had a tendency to accumulate trace metals and some nutrients.

Table 8: Mean values of chemical parameters within the sediments of the earthen ponds at Delta Breeding Station after 3, 6 and 9 months from the stocking of fish and their Std. error and the significant variation among them

Physico-chemical parameters	df	Mean			Std. Error			P-value (2-tailed)		
		After 3 months	After 6 months	After 9 months	After 3 months	After 6 months	After 9 months	(3-6)	(3-9)	(6-9)
PH	10	7.5427	7.2564	6.6755	.07903	.06884	.08257	*0.010*	*0.000*	*0.001*
CO_3^{2-} (mg kg^{-1})	10	a	a	a	a	a	a	a	a	a
HCO_3^- (mg kg^{-1})	10	116.4545	131.4273	142.5364	4.3875	3.9757	3.8865	*0.018*	*0.001*	*0.004*
EC (dS m^{-1})	10	0.5783	0.6721	0.7621	0.0173	0.0219	0.0271	*0.000*	*0.000*	*0.001*
Ca^{2+} (mg kg^{-1})	10	45.2273	48.1818	52.0909	2.1398	1.9854	2.1082	*0.001*	*0.000*	*0.004*
K^+ (mg kg^{-1})	10	15.4273	19.2273	23.5455	0.7843	1.2198	1.2549	*0.006*	*0.000*	*0.004*
Mg^{2+} (mg kg^{-1})	10	15.0182	18.5182	22.0364	0.5538	0.8551	1.1535	*0.001*	*0.000*	*0.001*
Na^+ (mg kg^{-1})	10	33.3182	39.8182	45.2727	1.1287	1.5656	1.6954	*0.002*	*0.000*	*0.001*
Cl^- (mg kg^{-1})	10	81.5000	96.4182	111.6636	2.9981	4.3311	6.0064	*0.000*	*0.000*	*0.001*
NO_2^- (mg kg^{-1})	10	0.2864	0.2964	0.3518	0.0253	0.0956	0.0101	**0.744**	**0.056**	*0.000*
NO_3^- (mg kg^{-1})	10	11.2909	13.5091	15.3636	0.8125	0.9091	0.7822	*0.000*	*0.002*	*0.046*
NH_4-H^+ (mg kg^{-1})	10	8.2273	10.0818	11.2273	0.5052	0.4825	0.5652	*0.000*	*0.000*	*0.033*
PO_4^{3-} (mg kg^{-1})	10	6.3903	7.9091	9.1636	0.5817	0.4988	0.5971	*0.002*	*0.000*	*0.013*
SO_4^{2-} (mg kg^{-1})	10	54.7273	62.7273	73.1818	2.5382	3.8778	4.3752	*0.003*	*0.000*	*0.006*
Al (mg kg^{-1})	10	52843.64	50683.64	51790.91	1887.640	1930.201	1724.649	**0.189**	**0.389**	**0.258**
As (mg kg^{-1})	10	a	a	a	a	a	a	a	a	a
Ba (mg kg^{-1})	10	398.1818	449.8182	530.6364	19.13342	18.00092	21.4019	*0.034*	*0.000*	*0.007*
Cd (mg kg^{-1})	10	4.8181	6.0000	9.4545	0.6441	0.5721	0.7788	*0.002*	*0.000*	*0.000*
Co (mg kg^{-1})	10	31.0909	46.6364	49.3636	5.49951	5.13858	4.76211	*0.000*	*0.000*	**0.104**
Cr (mg kg^{-1})	10	119.0909	149.0000	163.2727	12.1471	27.8593	34.9646	**0.095**	**0.088**	**0.211**
Cu (mg kg^{-1})	10	155.0000	198.0000	250.7273	9.5051	16.3384	27.7466	*0.042*	*0.009*	*0.048*
Fe (mg kg^{-1})	10	50934.55	58004.55	63677.18	1868.12	1673.01	2908.29	*0.028*	*0.001*	*0.048*
Mn (mg kg^{-1})	10	578.9091	696.3636	829.0909	31.75945	58.48485	71.38238	*0.050*	*0.001*	*0.025*
Mo (mg kg^{-1})	10	a	a	a	a	a	a	a	a	a
Ni (mg kg^{-1})	10	0.0000	85.7273	103.5455	0.0000	2.16623	1.88469	*0.000*	*0.000*	*0.000*
Pb (mg kg^{-1})	10	17.9091	37.6364	42.8182	2.59529	3.03696	3.04756	*0.000*	*0.000*	*0.004*
Sb (mg kg^{-1})	10	a	a	a	a	a	a	a	a	a
Se (mg kg^{-1})	10	a	a	a	a	a	a	a	a	a
V (mg kg^{-1})	10	695.5455	710.8182	725.7273	140.2547	141.2542	145.5803	*0.001*	*0.001*	*0.016*
Zn (mg kg^{-1})	10	194.6364	408.4545	441.1818	42.3709	59.5750	55.2591	*0.009*	*0.002*	*0.050*
O.M (g kg^{-1})	10	19.473	25.145	33.445	0.1496	0.1879	0.2393	*0.000*	*0.000*	*0.000*

- **df = degree of freedom, Std. Error = standard error of the mean, P-value =attained level of significance**
- **Bold Value (P) >0.05 - *Italic Value* (P) <0.05**
- **a Could not be computed because the concentrations are the same.**

The fixation**/**mobilization potential of the sediment with respect to heavy metals is dependent on the pH. The increase in pH in some locations promotes the precipitation of metals, which subsequently settle to the bottom of the earthen ponds and ultimately result in reduced water columns concentrations and perhaps increased concentrations of metals in sediments (Förstner and Wittmann, 1983). On the other hand, the decrease in the pH value may be attributed to the decomposition of descending plankton and organic matter which lead to the release of hydrogen sulfide and the formation of organic acids (Abdel-Satar, 2005).

The high percentage of organic matter within the sediment was mainly produced from waste product of protein metabolism by fish excretion, through the feeding system, dead plankton, and decaying aquatic weeds and fish. Such organic matter acts as a metal carrier and plays an important role in the metal distribution patterns within the sediment (Lin and Chen, 1998).

Intensive fish aquaculture can lead to higher proportion of organic materials and fertilizers such as ammonia, nitrate and phosphate compounds as well as the high proportion of heavy elements in the water and sediments (Madhav and Lin, 1996; Ali and Abdin, 2003; Bakry *et al*., 2004; Jawad *et al*., 2004; Ali *et al*., 2006; Tohamy *et al*., 2006 and El-Kholy, 2013). Similarly the present study show that during rearing of the grass carp of different sizes in the earthen ponds, the quality of the sediment has been changed with increasing the time. The values of pH have been statistically decreased. While the values of (Ec), (HCO_3^-), (Ca^{2+}), (K^+), (Mg^{2+}), (Na^+), (Cl^-), (NO_2^-), (NO_3^-), (NH_4-H^+), (PO_4^{3-}), (SO_4^{2-}) and the heavy metals (Ba), (Cd), (Co), (Cr), (Cu), (Fe), (Mn), (Ni), (pb), (V) and (Zn) have been statistically increased as well as the percentage of organic matter (O.M %).

Concerning the anions and cations in the sediment, the results show that most of their values attained the highest values, especially within the earthen ponds used for rearing the breeders of grass carp. The most predominant anions are chloride and sulfate. In case of the cations, the results show large variation in the cation contents however the highest values were achieved upon increasing the time of stocking of fish especially in earthen ponds stocked with breeders of grass carp. This result agrees with that stated by Abd El-Fattah (1994) who mentioned that both cations and anions increased with increasing the load of water pollutants.

In addition, the heavy metals in the earthen ponds whish were stocked with breeders were higher than those of those stocked with fry and fingerlings of grass carp. This result is mainly attributed to the feeding process and the organic matter percentages. Moreover, it is clear that the sediments act as a major sink for pollutants in the aquatic environment. Furthermore, it is clear that heavy metals accumulate in the sediments through complex chemical adsorption mechanisms depending on the nature of the sediment matrix and the properties of the adsorbed compounds (Maher and Aislabie, 1992). The adsorption process is influenced by several chemical parameters such as: pH, oxidative–reductive potential, dissolved oxygen, organic and inorganic carbon content, and the presence of some anions and cations in water phase that can bind or co-precipitate the water-dissolved or suspended pollutants (Wen and Allen, 1999). The concentration of such metals in the water column can be relatively low, if it is compared with their concentrations in the sediment. Low-level discharges of a contaminant may meet the water quality criteria, but long-term partitioning to the sediment could result in the accumulation of high loads of pollutants (Binning and Baird, 2001). Therefore, the monitoring of accumulation of such trace metals in the sediment is fundamental to realized pollutant and its main cause.

The present result showed that the mean concentrations of heavy metals in the water of the Nile River at El Kanater El-Kairia tended to be in the order of Fe > Mn > Zn > Pb > Cu > Ni > Cd. Concerning the artificial diet, it had slightly the same order except for Pb (Fe > Mn > Zn > Cu > Ni > Pb > Cd). Interestingly, in the polluted sediment, the order of abundance of the heavy metals followed the same trend like the artificial diet except for the sediment after 3 months from stocking of fish. The trend of the abundance of heavy metals was Fe > Mn > Zn > Cu > Pb > Cd > Ni; Fe > Mn > Zn > Cu > Ni > Pb > Cd; and Fe > Mn > Zn > Cu > Ni > Pb > Cd, after 3, 6 and 9 months from the stocking of fish, respectively. This suggests that the values of the heavy metals in the sediment are mainly attributed to the feeding process and the presence of organic matter which is oxide in the accumulation of the heavy metal to the sediment under oxic conditions. Also, it is clear that the ability of surface sediment in the earthen ponds to accumulate heavy metals from the water is variable and the mobilization of some chemical parameters from the sediment to water and vise versa is depending on some physical factors which include temperature and water turbulence.

Also, the high concentrations of the pollutants in the bottom sediment are considered indication for water content of those pollutants depending on the adsorption process which depends mainly on the grain size distribution of the bottom sediment and its chemical contents of the organic matter in association with intensive feeding process, consumption of food and deposition of fecal matter which represents the main cause of such pollutants. This statement coincides with the finding of Ali and Abdin (2003); MALR, (2003) and Ali *et al*. (2006) who found high concentration of organic matters and some heavy metal in the bottom sediment underneath the floating cages from feeds. Also, Tohamy *et al*. (2006) found high nutrient load in the sediment of earthen pond stocked with grass carp. Sundstrom *et al*. (1988) found that the sediment within the pond stocked with catfish (*Ictalurus punctatus*), contained relatively high levels of calcium (Ca) and magnesium (Mg), and had a high base saturation percentage of phosphorus (P), potassium (K), copper (Cu), zinc (Zn) and manganese (Mn) levels.

Recommendations

It is very important to provide good environmental condition to fish in order to have good result in nursery operation. Thus, pond preparation needs to be carried out before the stocking of fish in order to remove the pollutants from the sediment by using both natural and chemical treatments.

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تداعيات المزارع السمكية المائية على نوعية الرسوبيات داخل الأحواض الترابية في محطة تربية الدلتا

حسن حمزه عباس، عصمت حسن نوفل، محمد عبدالسلام عبدالمجيد، ياسر محمود علي، مها محمود علي

كلية الزراعة، جامعة بنها – معهد بحوث البيئة، معهد بحوث صيانة القنوات المائية، المعامل المركزية للرصد البيئي، المركز القومي لبحوث المياه.

بدأت تربية الأحياء المائية المصرية مع استخدام تقنيات تقليدية واسعة وشبه مكثفة. وقد حدثت تنمية للمزارع المائية السمكية سريعا في السنوات الأخيرة، عرف أنها أفضل حل للحد من الفجوة المتزايدة بين العرض والطلب على الأسماك. ومع ذلك، هناك الكثير من القلق حول زيادة تركيز المغذيات والعناصر النادرة في رسوبيات الأحواض الترابية نتيجة عملية تربية الأسماك في أحجام وأعمار مختلفة. وانطلاقا من هذا، قد أجري هذا البحث لدراسة خصائص رسوبيات القاع للبرك الترابية في محطة تربية الدلتا (DBS) لتحديد المشاكل التي تنشأ من الأنشطة المختلفة وخاصة التي تسبب تلوث الرسوبيات خلال تربية أسماك مبروك الحشائش.

وقد أظهرت النتائج المتحصل عليها أن قوام الرسوبيات في البرك الترابية متماثلا تقريباً حيث أنه تراوح من الطميية الرملية إلي الطميية. وذلك، خلال تربية أسماك مبروك الحشائش في أحجام مختلفة في الأحواض الترابية، وقد حدث تغيير على نطاق واسع في نوعية الرسوبيات بعد 3 و 6 و 9 أشهر من تربية الأسماك. وقد بينت النتائج أن قيم درجة الحموضة قد انخفضت إحصائيا. في حين أن قيم التوصيل الكهربائي (EC)، بيكربونات (HCO3)، الكالسيوم (Ca)، البوتاسيوم (k)، المغنيسيوم (Mg)، الصوديوم (Na)، الكلوريد (Cl)، النتريت (NO_2)، نترات (NO_3)، الأمونيا (NH_4-H)، فوسفات (PO_4)، كبريتات (SO_4) والمعادن الثقيلة الباريوم (Ba)، الكادميوم (Cd)، الكوبالت (CO)، الكروم (Cr)، النحاس (CU)، الحديد (Fe) والمنغنيز (Mn)، النيكل (Ni)، الرصاص (Pb)، الفاناديوم (V) و الزنك (Zn) قد زادت إحصائيا وكذلك نسبة المواد العضوية (O.M). بالإضافة إلى ذلك، تميزت الرسوبيات في الأحواض الترابية المحتوية علي أمهات مبروك الحشائش بأعلى القيم من الأنيونات والكاتيونات والمعادن الثقيلة في الرسوبيات مقارنة بالرسوبيات في الأحواض الترابية التي أحتوت علي إصبعيات مبروك الحشائش. ويعزى هذا أساسا إلى عملية التغذية.