IMPACT OF DREDGED MUDDY BOTTOM AND SEDIMENTS ON CYANOBACTEIAL BLOOMS, CHLOROPHYLL A, ZOOPLANKTON, WATER QUALITY, HEAVY METALS AND COLLECTED FINGERLINGS IN NILE TILAPIA PONDS

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Abstract

This study investigated the impact of dredged sediment, (sludge, or muck) on the cyanobacteial blooms, chlorophyll a concentrations, zooplankton production, water quality, heavy metals and Nile tilapia spawning.

Twelve earthen ponds each of 4200-m2 (1 Feddan) areas, six of them were renovated and enlarging by dredging and dumping the sediment in ponds characterized by muddy bottoms. All ponds were stocked with Nile tilapia fry (0.1±0.02 gm) at a density of 6000 fish/ feddan.

Cyanobacteria was the most dominant division in the two management systems, in un-dredged ponds represented 69.7% and 47% in dredged ones of the total phytoplankton abundance. *Anabaena* sp. and *Microcystis* sp. were observed to dominate the assemblage at all ponds, and occurred in quantities that could be considered strong cyanobacterial blooms. The contribution of *Anabaena* sp. to the total phytoplankton abundance varied from 20.54-43.46 %, while *Microcystis* sp. from 11.91 and 19.85% in dredged and un-dredged ponds, respectively. High variation was more pronounced, with reduction in the rates of phytoplankton production and chlorophyll a concentrations recorded in the waters, at the dredged ponds.

Copepoda and rotifera dominated dredged ponds, while cladocera dominated un-dredged ones. The total count of zooplankton in dredged ponds was higher than that of un-dredged ones.

Water quality was enhanced in dredged ponds. Low dissolved oxygen, high unionized ammonia, total alkalinity, total hardness, and high heavy metals in both water and fish are recorded in un-dredged ponds.

The total fish production, condition factor and the total average number of fingerlings of Nile tilapia collected from natural spawning of dredged ponds was significantly higher than that of un-dredged ones.

The results of this study will be useful as an alarm signal to improve biological characteristics, water quality, minimize the rate of pollution of heavy metals in both pond water or fish, increase fish production and for the management programs of dredging the sediments from the muddy bottom pond that suffer from sludge, or muck.

INTRODUCTION

Impacts of anthropogenic activities such as dredging and reclamation are well documented (Chong and Chou, 1992). Sediment or muck removal is dramatically reducing weed and algae problems, greatly increasing water quality for a healthy environment and expanding living space for fish.

Excess sediments can cause several problems in ponds. Sediments may cover fish eggs or make spawning beds less accessible or attractive to fish. High sediment loads in ponds can suffocate fish eggs and young, reduced fish food availability and off-flavor in food fish (Hargreaves, l999).

Large build-ups of organic sediment, sludge, or muck are commonplace in many water bodies. This is the result of precipitation of nutrients and organic matter entering the pond water through runoff containing fertilizer in many years. Beamud *et al.*, 2007 viewed that phytoplankton population changes with relation to environmental factors, as well as the significance of nitrogen limitation on the phytoplankton yield. Lake's sediments were the source of nutrients. Sedimentation can make a pond shallower or make the bottom less firm, oxygen levels may drop in ponds with lots of organic sediment; in some cases the decomposition of organic sediments produces offensive odors.

When organic sediment (sludge) accumulates, unpleasant odor and fish kills in lakes due to the lack of oxygen and high levels of toxic gases (Morse 1994; Møller and Riisgård, 2007).

Organic sediments accumulate in highly productive ponds with lots of algal growth (Møller and Riisgård, 2007). Some methods such as chemicals work to reduce algae; they are dangerous to the fish and can be harmful to the environment (Anderson 1997). Chemical additives temporarily relieve the symptoms of a poor aquatic environment, but do not cure the problem.

Dredging can remove muck and sediment during the process, as well as provide a better habitat for fish. Dredging, however, only treats symptoms of excessive plant and algae growth, rather than the cause, which is excessive nutrient loading, usually through runoff. Dredging improve water quality, control algal blooms, reduce odor, prevent fish kills or improve fish health and growth. Long-term effects of dredging should be a reduction in aquatic vegetation if the depth is beyond the photic zone. A few studies involving in situ bioassays have concentrated on fish, macroinvertebrates, cladocerans, and periphyton (Santos *et al.*, 2002; Nayar *et al.*, 2004 and Simonini *et al.*, 2005).

This study investigated the impact of dredged sediment, (sludge, or muck) on the cyanobacteial blooms, chlorophyll a concentrations, zooplankton production, water quality, heavy metals in both pond water or fish and Nile tilapia spawning.

MATERIALS AND METHODS

Pond facilities and design

Twelve earthen ponds each of 4200-m^2 (1 feddan) areas at the WorldFish Center (Abbassa, Sharkia Governorate, Egypt), six of them were renovated and enlarging by dredging and dumping the sediment in earthen ponds characterized by muddy bottoms. Ponds were completely drained and bottom sediment allowed time to dry. Dredging was mechanically removed with heavy equipment, (bulldozer). These ponds were supplied with freshwater derived from El-Ismailia canal throughout El-Gadoon canal; water was filtered through saran screen to prevent the entrance of wild fish, their eggs and larvae. The study was conducted from May 2005 to May 2006.

All ponds were stocked with Nile tilapia fry (0.1±0.02gm at a rate of 1.5 fish /m^2. Ponds were fertilized by 50 kg chicken manure /feddan /week for 10 weeks, then applied feeding at a rate of 3% of fish biomass for the rest period. No feeding was applied during the winter season.

Water physicochemical analysis

Samples were collected and analyzed monthly during the winter, biweekly during the spring and fall and weekly during the summer months. Parameters measured at the time of collection included water temperature (°C) and dissolved oxygen (DO mg L^{-1}) using an oxygen electrode meter. One-liter water samples were collected in 1-L polyethylene bottles to measure hydrogen ions concentration (pH) at room temperature, using the ACCUMET pH meter (model 25), and total ammonia (mg L^{-1}) using HACH Comparison (1982). Total alkalinity, total hardness, available phosphorus and nitrate (NO_3) were determined according to Boyd and Tucker (1992).

Chlorophyll and phytoplankton estimation

Chlorophyll a concentrations are determined photometrically using spectrophotometer (Vollenweider, 1969). Quantitative estimation of phytoplankton was carried out by the technique adopted by APHA (1985) using the sedimentation method. Phytoplankton samples were preserved in Lugol's solution. Sedgwick-Rafter cell was microscopically used for counting after identification of phytoplanktonic organisms. The phytoplankton cells were identified to four divisions as, diatom (Bacillariophyceae), blue-green algae (Cyanobacteria), green algae (Chlorophyceae) and euglenoids (Euglenophyceae). For identification of the algal taxa, Fritsch (1979) and Komarek and Fott (1983) were consulted.

Zooplankton estimation

Quantitative analysis for zooplankton samples were taken biweekly. Ten liters from the pond water were filtered through zooplankton net of 55 μm mesh diameter. Samples were preserved immediately after collection using 4% neutral formalin. Total zooplanktons were determined following Ludwig (1993).

Heavy metals

Atomic absorption spectrophotometer (Thermo 6600, Thermo Electron Corporation, Cambridge, UK) was used for measuring heavy metals. The monthly pond water samples were filtered by Millipore filter throughout Millipore filter paper (0.45 µ), the metals were measured in the filtrate. For measuring metals residue in fish muscles, fish samples were oven dried at 85°C until constant weight. A 1.0 g dry weight was ashes in muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) for 6 hours. Ash was digested with conc. HNO_3 using muffle furnace, and diluted with 2 N HCl to a constant volume. Metals were determined.

Statistical analysis

One-way ANOVA was used to evaluate the significant difference among treatments and duration. A probability at level of 0.05 or less was considered significant. All statistical analyses were run on the computer, using the SAS program (SAS, 2003).

RESULTS AND DISCUSSION

I- Plankton

i- Phytoplankton Standing Crop

Composition of the dominant phytoplankton species was investigated in order to understand variability in the different species contributing to the overall primary production in the Nile tilapia ponds (Table 1). Cyanobacteria was the most dominant division in the two management system, it was higher in un-dredged ponds represented 69.7% and 42.16% in dredged ones of the total abundance. These results revealed that Nile tilapia in un-dredged ponds failed to control and overcome Cyanobacteria so, high phytoplankton abundance was exhibited. On the other hand, the low phytoplankton abundance in dredged ponds may be attributed to the efficient grazing by zooplankton and/or fish. Blue green algae (Cyanobacteria) are considered less desirable for Nile tilapia growth than green algae (Chlorophyceae) (Turker *et al.*, 2003).

Anabaena sp. and *Microcystis* sp. were observed to dominate the assemblage at all ponds. These species occurred in quantities that could be considered strong cyanobacterial blooms. The contribution of *Anabaena* sp. were varied from 20.54 to 43.46 % and *Microcystis* sp. varied from 11.91 to 19.85% of the total abundance in dredged and un-dredged ponds, respectively. Van de Bund and Van Donk (2004) found that algal blooms occurred at high nutrient levels. Beamud *et al.*, 2007 viewed that the sediments were the source of nutrients.

Less abundant Chlorophyceae species like *Chlorella vulgaris, Chlorella saccharophila, Chlorella elliposoidea, Chlorococcum humicola, Crucigenia reciangularis, Dictyospharium polchellam* and *Gonium sociale*, were recorded in un-dredged ponds which represented 10.08%, a higher abundance in dredged ones represented (26.7%). Bacillariophyceae abundance were higher in dredged ponds (28.05%) than in un-dredged ones (14.79%) of total standing crops. Euglenophyceae was the less dominant division in the two management systems. Other species were scarce and showed number of fluctuation throughout the study period.

Table 1.Phytoplankton species composition in percentage of the total phytoplankton abundance in waters of the un-dredged and dredged Nile tilapia ponds

1- Bacillariophyceae :	**Dredged**	**un-dredged**	**Cyanophyceae continue**	**Dredged**	**un-dredged**
Amphora ovalis **kütz.**	0.1	0.05	***Oscillatoria limnetica*** **Lemmer.**	0.9	-
Bacillaria paradoxa **Gmel.**	0.15	-	***Oscillatoria tenus*** **var.** ***natans*** **Gomont**	-	1.56
Cocconeis placentule **Ehr.**	-	0.03	***Spirulina*** **sp.**	1.2	-
Cyclotella comta **(Her.)Kütz.**	3.1	2.02	**No. of species**	14	13
Cyclotella ocellata **Pant.**	2.3	2.1	**% of total**	42.16	69.71
Cyclotella opaerculata **(Ag.)**	0.9	-	**3- Chlorophyceae :**		
Cymbella affinis **Kütz.**	-	0.31	***Actinastrum hantzschii*** **Lagerh.**	-	0.12
Diatoma hiemale	1.7	-	***Ankistrodesmus falcatus*** **(Chorda) Ralf**	0.91	-
Diploneis didyma **Ehr.**	-	0.08	***Botryococcus braunii*** **Kütz .**	0.93	0.38
Melosira granulata **(Ehr.) Ralfs.**	5.2	3.11	***Chlorella vulgaris*** **Beij.**	4.3	1.33
Melosira varians **Ag.**	4.1	2.3	***Chlorella saccharophila*** **(Kruged)**	3.7	0.31
Navicula cryptocephala **Kütz.**	1.1	-	***Chlorella*** **elliposoidea (Gerneck)**	2.9	-
Navicula cuspidata **Kütz.**	0.73	-	***Chlorococcum humicola*** **(Nag.)**	0.8	-
Navicula gracilis **Ehr.**	-	0.31	***Closterium kuetzingii*** **Bréb**	1.1	1.3
Navicula humerosa **Breb.**	-	0.52	***Crucigenia reciangularis*** **Nag**	1.3	0.91
Navicula anglica **Ralfs**	2.3	-	***Dictyospharium polchellam*** **wood**	-	0.3
Navicula viridula **Kütz.**	-	1.1	***Gonium sociale*** **(Duj.) warming**	1.6	1.05
Nitzschia closterium **(Ehr.)W.Sm.**	2.22	2.12	***Oocystis locustris*** **Chodat**	0.9	0.05
Nitzschia longissima **(Breb) Ralfs.**	1.2	-	***Pediastrum boryanum*** **(Turp.) Menegh**	0.3	0.15
Nitzschia aciculariz **Smith**	-	0.51	***Pediastrum duplex*** **Meyen.**	1.1	0.6
Surirella stratula **(Turp.)**	0.05	-	***Pediastrum simplex*** **var. radianus (af. Chodat)**	0.9	-
Synedra acus **(Kütz.)**	0.3	-	***Scenedesmus acuminatus*** **(Largerh) Chodat**	1.1	-
Synedra longissima **W.Sm.**	0.9	0.31	***Scenedesmus bijugatus*** **(Turp Kütz)**	0.6	-
Synedra ulna **Nitzsch.**	1.7	1.13	***Scenedesmus quadricauda*** **(Turp) Bréb**	1.1	1.31
No. of species	17	15	***Scenedesmus bijuga*** **(Turpin) Lageh**	2.1	0.91
% of total	28.05	14.79	**Spirogyra loxissima G.S. West.**	-	1.36
2- Cyanophyceae :			***Straurastrum paradoxam*** **Meyen**	0.93	-
Anabaena spiroides **Lemmer.**	6.62	12.11	***Tetraedron trigonium*** **(af. Reinsch)**	0.13	-
Anabaena flos-aquae	5.61	13.3	**No. of species**	19	14
Anabaena **circinalis**	8.31	18.05	**% of total**	26.7	10.08
Anabaenopsis circularis **(F.S.West.) Wol&Miller .**	1.13	0.52	**4- Euglenophyceae :**		
Chroococcus dispersus **(Keissl.) Lemmer.**	0.51	0.41	***Euglena acus*** **Ehr.**	0.97	0.92
Chroococcus limneticus **Lemm.**	0.33		***Euglena gracilis*** **Kelbs .**	-	0.81
Chroococcus minor **(Kütz.) Naegelli**	1.11	2.8	***Euglena spirogyra*** **Her.**	1.33	1.04
Gloeocapsa rupestris **kuetzing . Kütz .**	1.33	2.41	***Phacus longicauda*** **(Ehr.) Dujadin.**	0.79	1.01
Merismopedia tenusisema **Lemmer.**	-	0.25	***Phacus pleuronectes*** **(Muell) Dujardin .**	-	0.87
Merismopedia punctata **Meyen .**	1.1	0.46	***Phacus orbicularis*** **Heubner**	-	0.77
Microcystis aeriogínosa **.kutz. ; emend .Elenkin .**	8.3	15.54	**No. of species**	3	6
Microcystis incerta **Lemmer.**	3.61	4.31	**% of total**	3.09	5.42
Mrismopedia tenuissima **Lemmer .**	2.1	1.11	**Total No. of species**	53	48

Data in Table (2) showed that there were monthly significant ($P < 0.05$) variations in the count of total phytoplankton between un-dredged and dredged ponds. It was significantly higher in un-dredged ponds than those of dredged ones.

Dredging has been recognized as one of the major anthropogenic activities causing impacts in estuaries (Lu *et al.*, 2002). Few studies in estuaries have established that anthropogenic activities such as dredging and reclamation have affected the community structure and biomass of macrobenthic fauna (Chong and Loo, 1990; Chong and Chou, 1992 and Lu *et al.*, 2002). Similar studies involving dredged ecosystems, with effects on the biological communities have been reported from other parts of the world (Newell *et al.*, 1998; Karel, 1999; Van Dalfsen *et al.*, 2000 and Schoellhamer, 2002).

ii- Chlorophyll a pigment

Chlorophyll a exhibited a trend comparable to that of phytoplankton production, with high concentrations in the dredged ponds. Chlorophyll a content in un-dredged ponds was significantly higher than that of dredged ponds. Significant changes ($P < 0.05$) in chlorophyll a content were observed among different months in both systems (Table 2). This result was attributed to the high abundance of phytoplankton in un-dredged ponds than that of dredged ones. In this regard, Boyd (1990) reported that chlorophyll a content in an indicator to the biomass of phytoplankton.

Spatial variation was more pronounced, with reduced rates of phytoplankton production and chlorophyll a concentrations reported in the subsurface waters, especially at the dredged area (Nayar *et al.*, 2003 and Nayar *et al.*, 2005).

Table 2. Monthly average of total phytoplankton and chlorophyll a content ± SE in dredged and un-dredged Nile tilapia ponds.

	Total phytoplankton (org x 10^4 L^{-1})		Chlorophyll a content (µg L^{-1})	
Month after stocking	Dredged.	Un-dredged	Dredged.	Un-dredged
June	3038.8±30.2^{b}	5062.8±41.2^{a}	291.8±3.1^{b}	753.8±5.4^{a}
July	3454±33.3^{b}	4828.5±35.6^{a}	341.1±2.5^{b}	783.0±4.9^{a}
August	1900.8±20.2^{b}	3009.2±32.1^{a}	196.9±1.8^{b}	375.0±3.8^{a}
September	2709.3±22.2^{b}	3914.1±36.1^{a}	253.0±2.6^{b}	563.0±6.0^{a}
October	2480.9±18.5^{b}	3593.5±33.2^{a}	280.1±1.6^{b}	612.0±5.4^{a}
November	1615.4±17.6^{b}	3783.9±33.5^{a}	313.1±3.2^{b}	473.1±4.8^{a}
December	1801.7±21.3^{b}	2184.6±29.1^{a}	217.4±4.5^{b}	402.3±3.8^{a}
January	1759.5±25.1^{b}	2964.1±30.1^{a}	321.0±3.9^{b}	575.0±5.0^{a}
February	1955.2±19.1^{b}	2364.1±22.5^{a}	180.1±1.8^{b}	447.0±4.6^{a}
March	2052.0±23.5^{b}	2455.0±26.1^{a}	190.1±1.7^{b}	472.7±5.1^{a}
April	2098.4±18.9^{b}	3569.5±34.1^{a}	280.0±2.6^{b}	582.6±6.0^{a}
May	2635.4±24.5^{b}	3358.3±22.9^{a}	306.0±4.1^{b}	680.0±6.5^{a}
Mean	2291.8	3424.0	264.2	560.0

a, b. Values-having different script at the same row are significantly different ($P<0.05$)

iii- Zooplankton

Zooplankton included Cladocera, Copepoda, and Rotifers. The obtained data revealed that copepoda and rotifera dominated dredged ponds, while cladocera dominated un-dredged ponds. The total count of zooplankton in dredged ponds was higher than that of un-dredged ones (Table 3). Although, the phytoplankton abundance dominated by cyanobacteria increased in un-dredged ponds, the zooplankton abundance decreased. The zooplankton can not feed on the cyanobacteria blooms. Carmichael (1992) found that cyanobacterial blooms can be extremely harmful to zooplankters that feed on cyanobacteria. They may be directly lethal or they may reduce their offspring.

The changes in zooplankton count and structure are strongly affected by phytoplankton occurrence, and/or the impact of cultured fish. Yang *et al.* (2005) found that large changes in zooplankton community structure coincided with markedly changes in concentration of chlorophyll *a* and abundance of phytoplankton (Ali, 2003).

Table 3.The monthly abundance of zooplankton ±SE (org L^{-1}) in dredged and un-dredged Nile tilapia ponds.

Month after stocking	Rotifera (org L^{-1})		Copepoda		Cladocera org L^{-1})		Nauplii		Total zooplankton	
	Dredged	Un-dredged	Dredged	Un-dredged	Dredged	Un-dredged	Dredged	Un-dredged	Dredged	Un-dredged
Jun.	360±2.2^{a}	130±2.1^{b}	323±4.1^{a}	63±2.1^{b}	104±2.0^{b}	281±3.2^{a}	65±1.1^{a}	30±1.2^{b}	852±5.4^{b}	504±6.3^{a}
Jul.	320±3.0^{a}	177±2.4^{b}	263±3.3^{a}	89±1.9^{b}	82±2.4^{b}	190±1.9^{a}	60±1.2^{a}	32±1.5^{b}	725±7.6^{b}	488±4.5^{a}
Aug.	350±2.8^{a}	160±2.0^{b}	310±3.4^{a}	91±2.0^{b}	151±1.9^{b}	131±2.0^{a}	102±1.3^{a}	72±2.0^{b}	913±8.2^{b}	454±3.8^{a}
Sep.	190±1.5^{a}	130±1.5^{b}	101±2.1^{a}	62±1.5^{b}	44±1.1^{b}	70±2.1^{a}	43±1.0^{a}	47±2.4^{b}	378±4.3^{b}	309±2.8^{a}
Oct.	144±2.2^{a}	101±1.1^{b}	131±2.5^{a}	36±1.3^{b}	39±1.2^{b}	51±4.0^{a}	40±1.1^{a}	31±3.1^{b}	354±3.9^{b}	219±2.6^{a}
Nov.	120±1.1^{a}	93±1.5^{b}	60±2.0^{a}	28±2.0^{b}	12±1.0^{b}	50±2.5^{a}	15±0.8^{a}	19±1.8^{b}	207±2.9^{b}	190±1.8^{a}
Dec.	103±2.8^{a}	82±1.0^{b}	229±3.7^{a}	45±2.3^{b}	46±1.8^{b}	112±3.1^{a}	31±2.3^{a}	24±1.5^{b}	409±4.1^{b}	263±3.0^{a}
Jan.	96±1.5^{a}	62±2.0^{b}	380±4.5^{a}	13±1.0^{b}	52±2.0^{b}	220±4.1^{a}	53±2.7^{a}	11±0.9^{b}	581±5.4^{b}	306±4.1^{a}
Feb.	83±2.0^{a}	74±1.6^{b}	313±6.0^{a}	152±2.4^{b}	136±3.1^{b}	141±3.3^{a}	94±1.9^{a}	72±1.7^{b}	626±6.2^{b}	439±4.5^{a}
Mar.	132±3.0^{a}	101±2.4^{b}	333±5.1^{a}	132±2.1^{b}	126±3.4^{b}	291±5.0^{a}	135±3.0^{a}	65±2.1^{b}	726±7.3^{b}	589±6.1^{a}
Apr.	162±2.9^{a}	93±2.0^{b}	231±4.3^{a}	24±3.1^{b}	105±2.1^{b}	212±4.2^{a}	75±2.1^{a}	22±1.6^{b}	573±5.6^{b}	351±3.9^{a}
May	220±4.0^{a}	103±3.0^{b}	237±2.8^{a}	38±2.3^{b}	118±1.7^{b}	206±3.9^{a}	86±1.7^{a}	21±1.9^{b}	661±4.8^{b}	368±4.2^{a}
Mean	190.0	108.8	242.6	64.4	84.6	162.9	66.6	37.2	583.8	373.3

a, b. Values-having different script at the same row are significantly different ($P<0.05$)

Danish Skive Fjord suffers every summer from oxygen depletion in the near-bottom water causing large amounts of nutrients (phosphate and ammonia) to be released from the anoxic sediment. This subsequently stimulates a phytoplankton bloom, followed later on by an increase in the zooplankton. The surface chlorophyll a concentrations may become very high during periods with exceptionally severe oxygen depletion (Møller and Riisgård 2007).

II- Water Quality

Water quality management is undoubtedly one of the most difficult problems facing the fish farmer. Water quality problems are even more difficult to predict and to manage (Table 4).

As shown in Table (4), there was a significant difference ($P < 0.05$) in DO among different sampling months between both systems. The highest DO value (7.34 mg/l) was exhibited in dredged ponds, while the lowest one (3.08 mg/l) was recorded in un-dredged ponds. The overall average of DO concentration in dredged ponds (6.15mg/l) and un-dredged ones (4.46 mg/l) were significantly different.

Møller and Riisgård 2007 reported that severe cases of oxygen depletion take place because the blooming algae are not efficiently grazed, but settle to the bottom to be subsequently decomposed, leading to more severe oxygen depletion and killing fish.

Phytoplankton abundance would be the main source of DO in fish ponds which produced via photosynthesis. On the other hand, plankton and fish respiration consumed the DO that may cause depletion in DO. The microbial activity for oxidation of organic matter, which resulted from manure, fish faces and organism's death, was responsible for oxygen depletion. DO production by phytoplankton is depends on many other factors such as temperature, nutrients availability and grazing pressure by zooplankton and fish (Boyd, 1990).

Water temperature showed remarkable monthly variations. There was slight increase in water temperature in dredged ponds. The overall averages were 21.05 and 20.12 °C in dredged- and un-dredged ponds, respectively. Water temperature is one of the most influential environmental factors affecting pond dynamic and both the metabolism and growth of fish (Boyd, 1990). This result is due to the warm climate and the shallowness of most tropical fish ponds (~1.0 m) and warmer temperatures hold less oxygen (Boyd 1990).

The present study revealed that there were insignificant ($P > 0.05$) differences in pH value. The highest pH degree (9.27) was recorded in un-dredged ponds. However, pH values were within the acceptable limit for fish farming (7.68-9.27). These limits were proposed by different standard schemes (Boyd and Gautier, 2002).

Table 4. Average ±SE of some physico-chemical parameters during the period of investigation

	DO mg/l		Temp. °C		PO_4-P mg/l		NO_3-N mg/l	
Month	Dredged	un-dredged	Dredged	un-dredged	Dredged	un-dredged	Dredged	un-dredged
Jun.	6.09±0.2^{a}	3.96±0.2^{b}	26.96±1.1^{a}	26.03±1.2^{a}	0.36±0.03^{a}	0.11±0.01^{b}	0.1±0.02^{a}	0.05±0.003^{a}
Jul.	6.1±0.3^{a}	3.7±0.3^{b}	30.03±1.3^{a}	29.1±1.3^{a}	0.06±0.01^{a}	0.02±0.002^{a}	0.07±0.004^{a}	0.07±0.004^{a}
Aug.	5.41±0.4^{a}	3.08±0.1^{b}	29.01±1.1^{a}	28.08±0.9^{a}	0.06±0.01^{a}	0.03±0.003^{a}	0.06±0.004^{a}	0.11±0.02^{a}
Sep.	5.3±0.6^{a}	3.4±0.4^{b}	25.93±0.9^{a}	25±1.1^{a}	0.06±0.02^{a}	0.02±0.001^{a}	0.12±0.03^{a}	0.09±0.005^{a}
Oct	5.79±0.4^{a}	4.16±0.3^{b}	20.61±0.8^{a}	19.68±1^{a}.0	0.33±0.04^{a}	0.23±0.02^{b}	0.09±0.004^{b}	0.17±0.03^{a}
Nov	5.44±0.7^{a}	3.78±0.2^{b}	17.98±0.5^{a}	17.05±0.8^{a}	0.15±0.03^{a}	0.04±0.001^{b}	0.11±0.003^{a}	0.04±0.001^{b}
Dec.	7.34±0.6^{a}	5.55±0.4^{b}	12.73±0.6^{a}	11.8±0.9^{a}	0.33±0.05^{a}	0.03±0.002^{b}	0.14±0.004^{b}	0.26±0.03^{a}
Jan	6.71±0.4^{a}	5.93±0.5^{b}	12.81±0.7^{a}	11.88±0.7^{a}	0.12±0.02^{a}	0.03±0.002^{b}	0.32±0.02^{b}	0.59±0.03^{a}
Feb.	6.34±0.3^{a}	5.77±0.4^{b}	16.51±0.6^{a}	15.58±1.0^{a}	0.6±0.06^{a}	0.05±0.003^{b}	0.91±0.02^{a}	0.65±0.05^{b}
Mar	6.61±0.4^{a}	5.3±0.4^{b}	18.51±0.9^{a}	17.58±0.8^{a}	0.27±0.04^{a}	0.07±0.002^{b}	0.48±0.01^{a}	0.36±0.04^{b}
Apr	6.41±0.5^{a}	4.54±0.3^{b}	20.01±1.0^{a}	19.08±0.7^{a}	0.3±0.03^{a}	0.07±0.003^{b}	0.5±0.03^{a}	0.39±0.06^{b}
May	6.22±0.3^{a}	4.38±0.1^{b}	21.51±1.1^{a}	20.58±1.1^{a}	0.3±0.02^{a}	0.07±0.004^{b}	0.51±0.04^{a}	0.43±0.07^{b}
Avg.	6.15	4.46	21.05	20.12	0.25	0.06	0.45	0.27
Jun.	8.29±0.43^{a}	9.26±0.82^{a}	0.096±0.011^{b}	0.36±0.09^{a}	130±3.6^{b}	210±4.5^{a}	156.6±2.1^{b}	223.3±2.2^{a}
	PH		NH_3-N mg/l		Total alkalinity mg/l		Total hardness mg/l	
Month	Dredged	un-dredged	Dredged	un-dredged	Dredged	un-dredged	Dredged	un-dredged
Jul.	7.82±0.34^{a}	8.84±0.79^{a}	0.052±0.005^{b}	0.44±0.07^{a}	140±4.5^{b}	215±3.8^{a}	161.3±3.1^{b}	203.3±3.3^{a}
Aug.	7.81±0.52^{a}	8.76±0.83^{a}	0.072±0.007^{b}	0.21±0.05^{a}	135±2.9^{b}	230±2.8^{a}	159.3±1.2^{b}	204±3.4^{a}
Sep.	7.95±0.48^{a}	8.67±0.56^{a}	0.036±0.031^{b}	0.32±0.06^{a}	130±1.6^{b}	220±3.0^{a}	172±2.2^{b}	221.4±3.4^{a}
Oct	7.71±0.62^{a}	8.79±0.45^{a}	0.028±0.004^{b}	0.37±0.04^{a}	127.5±2.8^{b}	235±3.5^{a}	165±1.8^{b}	263.3±2.1^{a}
Nov	7.74±0.57^{a}	8.66±0.62^{a}	0.028±0.006^{b}	0.08±0.004^{a}	135±3.7^{b}	215±2.8^{a}	188±2.0^{b}	166.3±1.9^{a}
Dec.	7.68±0.47^{a}	9.05±0.45^{a}	0.024±0.003^{b}	0.12±0.006^{a}	140±4.1^{b}	190±1.9^{a}	157±1.9^{b}	170±2.5^{a}
Jan	7.91±0.68^{a}	8.56±0.70^{a}	0.212±0.04^{b}	1.08±0.21^{a}	148.3±4.5^{b}	198.8±2.3^{a}	146±1.7^{b}	198±4.0^{a}
Feb.	7.94±0.62^{a}	8.75±0.53^{a}	0.428±0.006^{b}	0.55±0.06^{a}	145±3.9^{b}	188.8±1.7^{a}	170±2.2^{b}	250±4.8^{a}
Mar	8.51±0.53^{a}	9.1±0.74^{a}	0.172±0.03^{b}	0.25±0.04^{a}	143.3±3.1^{b}	185±2.7^{a}	173.2±1.7^{b}	250±4.0^{a}
Apr	8.22±0.47^{a}	9.27±0.62^{a}	0.348±0.05^{b}	0.68±0.12^{a}	128.8±2.8^{b}	201.9±3.2^{a}	180±2.1^{b}	250±2.9^{a}
May	8.04±0.73^{a}	9.22±0.54^{a}	0.52±0.06^{b}	1.1±0.09^{a}	146.7±2.7^{b}	218.8±3.6^{a}	184.1±2.2^{b}	330±3.3^{a}
Avg.	7.97	8.91	0.17	0.46	137.47	209.03	167.71	227.47

Total alkalinity values in un-dredged ponds were higher than those recorded in dredged ponds along the experimental period. There was significant ($P > 0.05$) difference in total alkalinity among different months between both systems. Teichert-Coddington *et al.* (1992) mentioned that the carbon dioxide release leads to carbonate solubility, while it's removing by phytoplankton for photosynthesis leads to increase carbonates and so, the increase of alkalinity. This mechanism explains why un-dredged ponds exhibited high alkalinity as compared to dredged ponds where the abundance of phytoplankton in un-dredged ponds was higher than that of dredged ones.

The total hardness in un-dredged ponds was higher than that of dredged ones. Total hardness at different months exhibited significant differences in both systems. The overall average of total hardness was 227.47 and 167.71 mg/L as $CaCO_3$ for un-dredged and dredged ponds, respectively.

The unionized ammonia in dredged ponds was lower than that of un-dredged ponds and significantly different. The overall averages of unionized ammonia were 0.17 and 0.46 mg/L for dredged and un-dredged ponds, respectively. The European Inland Fisheries Advisory Commission (EIFAC, 1973) stated that the toxic concentration of unionized ammonia to freshwater fish for short term exposure is 0.7-2.7 mg/L.

When oxygen is depleted in a water body, anaerobic bacteria partially break down the sediment. In the process, they expel hydrogen sulfide. Hydrogen sulfide is not only highly toxic to aerobic or good bacteria; it is also toxic to insects, and to fish at levels of 0.3 mg/l (a very low amount). The anaerobic (bad) bacteria also release ammonia into the water column. Ammonia feeds weeds and algae, and is toxic to fish at levels greater than 3.0 mg/l (Møller and Riisgård, 2007).

In dredged ponds, the overall average of nitrate concentration (0.45 mg/L) was slightly higher than that of un-dredged ponds (0.27 mg/L). Un-dredged ponds exhibited higher phytoplankton abundance, which could be quickly absorbed and accumulated nitrate inside phytoplankton cells (Boyd, 1990).

The obtained results revealed that available phosphorus concentration in dredged ponds were always higher than that of un-dredged ponds over the experimental periods. The overall averages of available phosphorus concentration in dredged and un-dredged ponds were 0.25 and 0.06 mg/L, respectively. Phosphorus could be absorbed and accumulated by bacteria, phytoplankton and sediments (Munsiri *et al.*, 1995). Therefore, the high abundance of phytoplankton in un-dredged ponds uptake more phosphorous than that of dredged ponds. Furthermore, phosphate in hard water could react quickly with calcium to form calcium phosphate, which would settle from the water within hours or days (Masuda and Boyd, 1994).

The overall averages of heavy metals concentrations (Fe, Zn, Mn, Cu, Cd and Pb) in un-dredged ponds water were higher than that in dredged ones as shown in (Table 5). Mackie *et al.*, (2007) reported that dredged area after remediation, dissolved and particulate metals (Cd, Co, Cu, Pb, Ni, and Ag) were found to be lower than levels in the un-dredged areas.

The impact of heavy metals on the aquatic environment is complex and depends on the physicochemical characteristics of water (Takasusuki *et al.*, 2004). Therefore, their toxicity limits have been based on hardness and total alkalinity (Perschbacher and Wurts, 1999) and pH (Masuda and Boyd, 1993) of the water.

Heavy metals concentrations in fish muscles were measured on dry matter basis (DW), as shown in Table (5). The heavy metals residues in the fish muscles of un-dredged ponds were significantly higher than that in dredged ones.

Table 5. Heavy metals in dredged and un-dredged Nile tilapia ponds

	pond water (µg/L)		Nile tilapia muscles (µg/g dry weight)	
Heavy metals	dredged	un-dredged	dredged	un-dredged
Fe	17.4±2.52 b	42.41±5.45	16.46±3.55 b	31.65±3.39 a
Zn	2.97±0.46	3.72±0.37	0.78±0.10 b	2.1±0.25 a
Mn	0.88±0.11	2.31±0.24	0.63±0.06 b	2.14±0.56 a
Cu	0.45±0.03	0.85±0.08	0.85±0.073 b	2.27±0.47 a
Cd	1.55±0.13	2.91±0.26	0.54±0.02 b	1.32±0.11 a
Pb	23.5±2.09	43.8±5.05	0.60±0.040 b	2.63±0.75 a

The bioaccumulation of heavy metals by fish organs accumulate in human blood and affect the public health (Hartung, 1972).With respect to the world levels of heavy metals in aquatic organisms, the values should be less than this range: 10-18 Fe, 50 Zn, 2.0-2.5 Mn, 20 Cu, 0.5-1.0 Cd and 0.05-2 Pb µg/g dry weight according to Turkish Food Codex (TFC 2002) and National Academy of Science (NAS 1980). It is clear that the concentrations of heavy metals were within the range of the world levels in the muscles of Nile tilapia in dredged ponds. While, the level of iron, cadmium and lead were above the permissible limits in the muscles of Nile tilapia in un-dredged ponds.

The study of Tam and Wong (1995) revealed very high concentrations of heavy metals in suspended particulates and sediments compared to the levels in water. Fine sediments have a larger surface area, which allows heavy metals and other contaminants to be adsorbed easily (Libes, 1992).

Table (6) showed that the total fish production in dredged ponds was significantly higher than that of un-dredged ones (1109.7 and 746.3 kg/feddan, respectively). There was a significant difference in condition factor of Nile tilapia in dredged and un-dredged ponds.

Table 6.Total production, condition factor and Nile tilapia fingerlings collected in dredged and un-dredged ponds.

parameters		dredged	un-dredged
Average final weight (g)		203.1±15.02 [a]	138.21±18.53 [b]
Average final fish length (cm)		20.1±0.62 [a]	18.8±0.76 [b]
Condition factor		2.50±0.06 [a]	2.08±0.02 [b]
Total production (kg/feddan)		1109.7±24.4 [a]	746.3±22.1 [b]
Fingerlings (Number / feddan)	≤ 2 g	9400±440 [a]	5500±330 [b]
	≥ 5 g	25200±730 [a]	18100±530 [b]
	Total	34600 [a]	23600 [b]

Condition factor represents the relationship between fish weight and length indicating to the fatness of fish (Power, 1990). This result revealed that the growth pattern of Nile tilapia in the two systems is different. Ostrowski and Garling (1988) reported that fish condition factor is a measure of relative growth of muscles to bone.

The total average number of fingerlings collected from natural spawning from dredged ponds was significantly higher than that in un-dredged ones (34600 and 23600 finger /feddan, respectively).

The Nile tilapia spawning and fry survival in dredged ponds was higher and better than that in un-dredged ponds. Excess sediments can cause several problems in ponds. Sediments may cover fish eggs or make spawning beds less accessible or attractive to fish. High sediment loads in ponds can suffocate fish eggs and young, reduced fish food availability and off-flavor in food fish (Hargreaves, l999).

Furthermore, un-dredged ponds exhibited cyanobacterial blooms, while Nile tilapia in un-dredged ponds failed to control and overcome Cyanobacteria. Blue green algae (Cyanobacteria) are considered less desirable for Nile tilapia growth than green algae (Chlorophyceae) (Turker *et al.*, 2003).

Dredging is only effective strategy to remove inorganic sediment, most direct method of organic sediment removal, removes nutrients, likely to improve habitat, water quality and can improve spawning habitat for many fish species (Karel, 1999)

Pond sediments can retain accumulated nutrients for many years, during which time they will continue to stimulate plant growth. Pond sediments dredged to remove accumulated stores of nutrients (Van de Bund and Van Donk, 2004).

Dredging is the only option for removal of inorganic sediments and is the most direct method of removing organic sediments. Dredging has many benefits to a pond besides simply increasing its depth and removing unwanted sediments (Tang *et al.*, 1997).

Dredging is more long lasting and ecologically sound than practices which target only the symptoms of nutrient enrichment. When the pond's basin is deepened significantly, nutrients from episodic runoff may be diluted in a greater volume of water. A primary consideration when dredging a pond is the fate of sediments that are removed. . If significant quantities of heavy metals or other pollutants are present in the sediments, the disposal process becomes even more complicated and expensive (Mackie *et al.*, 2007).

This will be useful as an alarm signal to improve biological characteristics, water quality, minimize the rate of pollution of heavy metals in both pond water or fish, increase fish production and for the management programs of dredging the sediments from the muddy bottom pond that suffer from sludge, or muck.

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تأثير تجريف الرواسبِ الموحلةِ على إزدهارِالسيانوبكتريا، كلوروفيل أ، إنتاج الزوبلانكتون، المعادنَ ثقيلةَ، الإنتاج الكلى وأصبعيات البلطى النيلىَ

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المعمل المركزى لبحوث الثروة السمكيه – مركز البحوث الزراعيه

تَحرّتْ هذه الدراسةِ تأثيرَ تجَريف الراسبِ (الأوحال أَو الروبة) على إزدهارِالسيانوبكتريا ، كلوروفيل أ ، تجمعَّات الزوبلانكتون، تركيز المعادنَ الثقيلةَ في الماءِ و السمك والإنتاج الكلى والأصبعيات الناتجة فى الأحواض.

خصص للدراسة إثنتا عشْرة حوضاً طينياً (ترابى) مساحة الحوض واحد فدان ٤٢٠٠م^{٢} ، تم تجَرْيف الراسبِ والتَخلّصُ منه بوضعه على الجسورلعدد ستّة أحواض. تم استزراعّ الأحواض بزريعة البلطى النيلىَ (٠,١±٠,٠٢ جم) بكثافة ٦٠٠٠ سمكةِ/ فدان.

سجلت السيانوبكتريا الهيمنة الأكثر في كلا النظامين ، و كانت أعلى في الأحواض الغيرِ المَجْرُوفةِ (٦٩,٧%) عنها في الأحواض المَجْرُوفةِ (٤٧ %) مِنْ الانتاج الكلى للهائمات النباتية. كان لنوعِ الأنابينا و الميكروسيست السَيْطَرَة على التجمّعَ في كل الأحواض وبكمياتِ يُمْكِنُ أَنْ تُعتَبرَ إزدهاراَ قوياً للسيانوبكتريا. تَفاوتتْ نسبة الأنابينا مِنْ ٢٠,٥٤- ٤٣,٤٦ %، و الميكروسيست بين ١١,٩١- ١٩,٨٥% من المحصول الكلى الهائمات النباتية في الأحواض المَجْرُوفةِ وغيرِ المَجْرُوفةِ، على التوالي. كَانَ الإختلاف العالي أكثرَ وضوحاً، فى إنتاجِ تجمعَّات الهائمات النباتية وكلوروفيلِ أ المسجّلتين في مياهِ الأحواض المَجْرُوفةِ.

أشارت النتائج أنّ الكبوبودا و الروتيفرا كانتا لهما السيطرة فى الأحواض المَجْرُوفةِ، بينما الكلادوسرا السيطرَة فى الأحواض غيرِ المَجْرُوفةِ. كَان العدد الكليّ للهائمات الحيوانية في الأحواض المَجْرُوفةِ أعلى مِنْ تلك فى غيرِ المَجْرُوفةِ.

تُحسّنتْ نوعيةَ الماءِ في الأحواض المَجْرُوفةِ. كان مستوى الأوكسجين الأقل، القلوية الكلية الأعلى، العسر الكليّ الأعلى، و مستوى المعادن الثقيلةِ الأعلى في المياهِ والسمكِ في الأحواض غيرِ المَجْرُوفةِ.

كَانتْ إنتاجية السمكِ الكليِّ، معامل الحالة والعددِ الكليِّ لإصبعيات البلطى النيليِ المجمعة والناتجة من التفريخ الطبيعى فى الأحواض المَجْرُوفةِ أعلى مِنْ تلك فى غيرِ المَجْرُوفةِ.

لذا توصى الدراسة بحتمية تجريف الراسب من قاع الأحواض التى تعانى من الأوحال أَو الروبة لتحسين الخصائص البيولوجية و خواص المياه وتقليل التلوث بالمعادن الثقيلة وزيادة انتاجية السمك.