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Heavy Metals and Chemical Composition of Mullet Fish and Water Quality of Its Farms

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Abstract:
Background: Fish is a source of high-quality protein, supplying respectively ≈6% and ≈16.4% of the world's and total animal protein requirements. Mullet production is mainly farm-based. Heavy metal accumulation in aquatic organisms is a serious sequel of aquatic system pollution. **Objectives:** to assess some heavy metal concentration and physiochemical composition of farm fish and water **Methods:** 60 mullet fish and 18 surface water samples were collected from three fish farms for determination of fish and water Cd, Zn, Cr, Cu and Pb concentrations as well as analysis of fish proximate chemical composition and water physiochemical parameters. **Results:** Only Pb and Zn exceeded the maximum permissible limit (MPL) in fish samples while Pb and Cd exceeded the MPL in water samples. Pb levels exceeded the MPL of fish (1.5 mg/kg) in 5% of fish samples while its concentration exceeded the MPL of water (0.01mg/l) in 50% and 33.3% of water samples during winter and summer respectively. Zn concentration exceeded the MPL (5 mg/kg) in about 6.5% of fish samples during winter season only. All water samples exceeded the MPL of Cd (0.003 mg/l) during winter only. Chemical analysis of fish revealed that there was no significant difference in protein content of mullet among different farms and between the two seasons. **Conclusion**: Pb and Zn accumulate in fish edible tissue inconsiderably high concentrations. Pb and Cd pollution should be monitored in fish farming water.

Key words: *Heavy Metals, Chemical composition, Water quality, Fish farms*

Abbreviations:

- Pb : Lead
- Cd : Cadmium
- Cu : Copper
- Cr : Chromium
- Zn : Zinc
- LSD : Least significant difference
- MPL: Maximum Permissible limit

INTRODUCTION

Heavy metals, as defined by Nieboer and Richardson (1980),[1] are natural trace constituents of the marine environment which occur at low concentrations, normally at the nanogram to microgram per liter, and function in combination with organic molecules, usually proteins. In recent times, heavy metal contaminants in natural aquatic ecosystems in excess of natural loads has become a problem of increasing concern. This

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has arisen as a result of the rapid growth of population, urbanization, industrial activities, exploration & exploitation of natural resources and irrigation and agricultural activities besides lack of environmental regulations.[2]

Seasonal variations have a potential to affect metal concentrations in estuarine organisms due to changes in physiochemical variables and some biological factors. Seasonal effects are critical in biomonitoring programs especially when sampling is undertaken at different times of the year.[3]

Aquatic organisms such as fish accumulate metals to concentrations many times higher than those present in water.[3,4]Heavy metals are capable of exerting considerable biological effects even at low levels. Variations in heavy metal concentration are related to levels of tolerance and toxicity symptom outbreaks, depending on species and period of passive accumulation.**[4]**

Living organisms including humans require varying amounts of iron, cobalt , copper, zinc, manganese and others. Excess heavy metals accumulation over time in the bodies of animals can damage the functions of the mental & central nervous system, vital organs (liver, kidneys, lungs) and production of the blood cells by bone marrow. Long-term exposure may result in slowly progressing neuro –mascular degenerative disorders (mimicking Alzheimer's disease, Parkinson's disease, muscle dystrophy, multiple sclerosis) , allergies and carcinogenesis.[5]

Our study searched for determining the concentration of some heavy metals (namely Cu, Zn, Pb, Cd and Cr) in farm mullet fish and water as well as analyses of mullet fish chemical composition (protein, lipid, ash & moisture) and farm water quality (, pH, salinity & temperature) during winter and summer seasons.

MATRIAL AND METHODS

A cross-sectional study was conducted in three different fish farms with different water salinity in2009/ 2010 winter (December, January, and February) and

2010 summer (July, August, September) seasons. Fish farms selected were El-Hager [farm I having fresh low salinity water] and Idku [farm II with slightly brackish medium salinity water] from El-Behira governorate and Mariout [farm III with slightly high salinity water] from Alexandria governorate

Study samples:

A total of 20 mullet fish(10 winter + 10 summer) weighing an average of 300-400 gms as preferable for human feeding and 6 water(3 winter + 3 summer) samples were collected from each farm. Water samples were collected using polyethylene bottles (2-liters capacity) properly cleaned with detergent for several days by distilled water and IN HCL.

Fish and water samples were transferred in an ice box to the Nutrition laboratory of the High Institute of Public health, Alexandria University for determination of:

1. Heavy metal [copper(Cu), zinc (Zn), lead(Pb) ,cadmium(Cd)&chromium(Cr)] concentrations in farm fish and water
2. Chemical composition (moisture, protein, ash and fat) of farm fish.
3. Water quality (temperature, salinity and pH) of farm water

Procedures:

1. Determination of Heavy metals (Cu, Zn, Pb, Cd and Cr)

1.1 In Fish:

The analysis were carried out according to UNEP/ FAO/ IAEA / IOC.The precision of the technique was tested by replicate analysis of metals using the reference material IAEA 350.The results were expressed in mg/g (ppm).[6] .

1.2 In farm water:

As heavy metals (dissolved and particulate) occur in water at concentration below the atomic absorption spectrophotometer sensitivity (AAS), so a pre-concentration step was necessary before measurements

Determination of Cd, Zn, Cr, Cu and Pb, were done using atomic absorption spectrophotometer (AA-6650 Shimadzu).[7]

2. Chemical composition (moisture, protein, ash and fat) of farm fish:

Fish samples were weighed, homogenized and kept in a well clean plastic bag and stored at deep freeze till analysis.

Moisture, ash, protein and fat determinations of edible fish tissue were carried out according to association of official's analytical chemists AOAC (2003).[8]

3. Water quality (temperature, salinity, pH)

Some parameters were totally or partially measured in the field i.e. as soon as the sample was collected

In situ, at each farm, water temperature was measured at the time of water sampling to the nearest 0.1°C by using an ordinary thermometer.

In situ, salinity was determined by measuring the electrical conductivity using an inductive salinometer (Beckman; model RS-10). Before use, the salinometer was standardized with standard seawater, Copenhagen, Denmark, of chlorinity 19.375 %.

The pH-value of water sample was measured in the laboratory immediately after collection using Bench type Electrochemistry Analyzer pH-meter (JENWAY, 3410) with reading up to 0.01 pH unit after necessary precautions in sampling and standardization processes.

Statistical Analysis

The experimental design was a factorial experiment in randomized complete block design with 156 replications in the two seasons. F-test and analysis of variance of treatments, ANOVA, difference was performed according to Steel and Torrie (1980). Statistical analysis was done by, F-test, and (least significant difference) L.S.D procedures available within the SAS software package.[9]

RESULTS

1. Fish samples:

Table 1: It is clear from the table that the level of Cu was significantly higher in summer than winter with highest level (9.320±8.146 mg/kg) in fish samples collected from Farm I

during summer. Other metals did not show this difference between summer and winter. Regarding winter season, the highest level of Cu (4.524±2.552 mg/kg), Pb (1.523±0.754 mg/kg) and Zn (3.555±1.474 mg/kg) were detected in farm I, while the highest level of Cr (3.436±1.626 mg/kg) and Cd (0.039±0.009 mg/kg) were detected in farm II. Regarding summer season, the highest level of Pb (0.873±0.576 mg/kg), Cr (2.580±0.825 mg/kg) and Cd (0.037±0.014 mg/kg) were detected in farm II, while the highest level of Cu (9.320±8.146 mg/kg) and Zn (3.459±0.819 mg/kg) were detected in farms I and III respectively.

Table 1: Heavy metal concentrations in winter and summer samples of farm mullet fish

Farm	Season	Cu (mg/kg)	Pb(mg/kg)	Zn (mg/kg)	Cr (mg/kg)	Cd(mg/kg)
Farm I	Winter	4.524^{b}±2.552	1.523^{a}±0.754	3.555^{a}±1.474	0.367^{c}±0.265	0.027±0.017
	Summer	9.320^{a}±8.146	0.133^{c}±0.163	1.484^{b}±0.484	0.736^{c}±0.532	0.022±0.016
Farm II	Winter	0.421^{c}±0.891	0.704^{b}±0.217	2.992^{a}±1.115	3.436^{a}±1.626	0.039±0.009
	Summer	1.200^{c}±0.969	0.873^{b}±0.576	2.892^{a}±0.961	2.580^{b}±0.825	0.037±0.014
Farm III	Winter	0.262^{c}±0.369	0.313^{c}±0.253	2.887^{a}±0.922	1.946^{b}±1.798	0.027±0.015
	Summer	4.962^{b}±2.797	0.164^{c}±0.155	3.459^{a}±0.819	1.949^{b}±0.688	0.032±0.010
$L.S.D_{0.05}$		2.258	0.264	0.622	0.689	0.0089

Mean value within a column not sharing a common superscript letter were significantly different p≤ 0.05.

Table 2: The lowest mean of moisture per cent age (64.086±2.695%) was detected in farm I during winter season, which was lowest significantly among all farms in both seasons. There was no significant difference in moisture percentage of Farm II and III among winter and summer season. The highest level of protein was detected in farm III during summer season while the lowest was detected in farm I also during summer season. There was a significant difference in the mean percentage of protein in fish samples of farm I between winter and summer. Farm I showed significantly higher percentage of fat during both seasons than that of farms II and III.

Table 2: Proximate analysis of winter and summer samples of farm mullet fish

Farm	Season	Ash (%)	Moisture (%)	Protein (%)	Fat (%)
Farm I	Winter	1.553±1.814	64.086^{b}±2.695	22.936^{a}±1.318	10.925^{a}±3.895
	Summer	1.083±0.184	74.257^{a}±0.979	18.031^{c}±1.155	6.629^{b}±1.516
Farm II	Winter	1.111±0.545	74.792^{a}±1.204	21.254^{b}±2.190	2.843^{c}±2.088
	Summer	1.260±0.658	73.806^{a}±1.641	21.199^{b}±1.836	3.735^{c}±2.504
Farm III	Winter	1.445±0.142	74.992^{a}±1.153	22.421^{a}±1.238	1.142^{c}±0.553
	Summer	1.344±0.116	73.722^{a}±1.005	23.414^{a}±0.820	1.520^{c}±0.528
L.S.D$_{0.05}$		0.530	0.962	0.805	1.347

Mean value within a column not sharing a common superscript letter were significantly different p≤ 0.05.

2. Water samples:

Table 3: It is clear that the level of Cu, Pb, Cr, Cd and Zn were significantly higher in winter than summer. Regarding winter season, the highest level of Cu (0.374±0.201 mg/l), Pb (0.263±0.037 mg/l) and Cd (0.013±0.003 mg/l) were detected in farm III, while the highest level of Cr (0.020±0.009 mg/l) and Zn (0.485±0.124 mg/l) were detected in farm I.

Table 4: The lowest salinity was detected in farm I that tend to be fresh water. Farm II tend to be brackish, while farm III tend to be salt. The Highest mean pH level (8.700±0.082) detected in farm II during summer season, which differed significantly from the other farms in both seasons. Water samples collected from farms I and III showed higher level of pH (8.277±0.137 and 7.630±0.085) respectively during summer season. Water samples collected from farm III and II showed insignificant differences in pH level (7.497±0.096 and 7.477±0.049) during winter season, compared to that detected in farm I during winter season (7.380±0.167), which revealed a significant difference with other farms in both seasons. There were insignificant differences among the three farms in the two seasons in temperature grades.

Table 3:Heavy metal concentrations in winter and summersamples of farm fish water

Farm	Season	Cu (mg/l)	Pb(mg/l)	Cr (mg/l)	Cd (mg/l)	Zn (mg/l)
Farm I	Winter	0.270^{b}±0.024	0.174^{b}±0.019	0.020±0.009	0.012±0.001	0.481^{a}±0.124
	Summer	0.011^{d}±0.004	0.011^{c}±0.003	0.003±0.003	0.000±0.000	0.013^{d}±0.006
Farm II	Winter	0.142^{c}±0.066	0.256^{a}±0.032	0.018±0.003	0.012±0.001	0.146^{c}±0.092
	Summer	0.019^{d}±0.018	0.023^{c}±0.006	0.000±0.000	0.000±0.000	0.012^{d}±0.007
Farm III	Winter	0.374^{a}±0.201	0.263^{a}±0.037	0.018±0.001	0.013±0.003	0.329^{b}±0.174
	Summer	0.018^{d}±0.012	0.010^{c}±0.004	0.003±0.000	0.001±0.000	0.008^{d}±0.008
$L.S.D_{0.05}$		0.048	0.014	0.0025	---	0.048

Mean value within a column not sharing a common superscript letter were significantly different p ≤ 0.05.

Table 4: Salinity, pH and temperature of winter and summer samples of farm fish water

Farm	Season	Salinity(ppm)	pH	Temperature(°C)
Farm I	Winter	2.267^{e}±0.137	7.380^{e}±0.167	21
	Summer	1.600^{e}±0.000	8.277^{b}±0.137	25
Farm II	Winter	4.000^{d}±0.000	7.477^{d}±0.049	22
	Summer	10.800^{c}±0.000	8.700^{a}±0.082	23
Farm III	Winter	16.800^{a}±3.288	7.497^{d}±0.096	22
	Summer	15.467^{b}±0.362	7.630^{c}±0.085	26
$L.S.D_{0.05}$		0.8431	0.072	---

Mean value within a column not sharing a common superscript letter were significantly different p≤ 0.05.

Table 5: Only Pb and Zn exceeded the MPL while other metals were within the permissible limits. It is shown that Pb level was higher than the maximum permissible limit (1.5 mg/kg) in 3 fish samples (representing 5% of the total number of samples) detected in two fish farms, 2 samples in farm I of winter season, and 1 sample in farm II of summer season.

Zn level was higher than the maximum permissible limit (5 mg/kg) in 4 fish samples (representing about13% of the number of samples collected during winter and about 6.5% of the total number of samples) detected in the three fish farms during winter season only, 2 fish samples were from farm I, 1 from farm II and 1 fish sample from farm III. No samples exceeded the MPL of Zn during summer season.

Table 5: Farm mullet fish samples with heavy metal concentrations exceeding their MPLs

Heavy Metal	Season	Farm	no.	Heavy metal (mg/kg)	MPL*[10]
Pb	Winter	I	2	2.423 2.745	1.5
	Summer	II	1	1.771	
Zn	Winter	I	2	5.786 5.775	5
		II	1	5.030	
			1	5.215	

MPL = Maximum Permissible limit

Table 6: Only Pb and Cd exceeded the MPL, while other metals were within the permissible limits. It is shown that Pb level was higher than the MPL (0.01 mg/l) in all the nine samples of the three farms during winter season (representing about 100% of the samples collected during winter and 50% of the total number of water samples) while during summer season, A total 6 samples (representing about 66.6% of the samples collected during summer and 33.3% of the total number of water samples) exceeded the MPL: 3 from farm II, 2 fromfarmIand1 from farm III.

Cd level was higher than the MPL (0.003 mg/l) in all the 9 samples of the three farms during winter season (representing about 100% of the samples collected during winter and 50% of the total number of water samples), while all samples collected during summer season were lower than the MPL.

No samples exceeded the MPL of Cd during summer season.

Table 6: Farm water samples with heavy metal concentrations exceeding their MPLs

Heavy Metal	Season	Farm	no.	Heavy metal (mg/l)	MPL*[11]
Pb	Winter	I	3	0.1974 0.1626 0.1611	0.01
		II	3	0.2787 0.2148 0.2729	
		III	3	0.2264 0.2538 0.3077	
	Summer	I	2	0.0129 0.012	
		II	3	0.0185 0.0305 0.0194	
		III	1	0.015	
Cd	Winter	I	3	0.0131 0.0119 0.0112	0.003
		II	3	0.0137 0.0119 0.0113	
		III	3	0.0089 0.0142 0.0155	

MPL = Maximum Permissible limit.

DISCUSSION

It is generally accepted that, heavy metal uptake occurs mainly from water, food, and sediment. However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism, and the contamination gradients of water, food, and sediment, as well as other factors such as salinity, temperature, and interacting agents.

A) Heavy metals in fish and water season variation:

Copper: In water samples, the mean Cu level ranged from 0.142 to 0.374 mg/l during winter season with the mean value of 0.258 mg/l, and ranged from 0.011 to 0.019 mg/l during summer season with the mean value of 0.015 mg/l. These results were in agreement with a study in USA revealing that copper in water ranged from

0.0005 to 1 mg/l,[12] and other studies in Canada and USA indicating that the copper level ranged from 0.005 to >30 mg/l.[13,14] In fish samples the mean Cu concentration ranged from 0.262 to 4.524 mg/kg during winter season with the mean value of 2.393 mg/kg, and ranged from 1.200 to 9.320 mg/kg during summer season with the mean value of 5.26 mg/kg. These results were higher than the maximum acceptable daily intake recommended by The World Health Organization which is approximately 1.3 mg/day.[15-17] Also it was higher than the recommended intake of copper for healthy adult men and women which is 0.9 mg/day.[16]

Lead: In water samples the mean Pb level ranged from 0.174 to 0.263 mg/l during winter season with the mean value of 0.219 mg/l, and ranged from 0.010 to 0.023 mg/l during summer season with the mean value of 0.017 mg/l. These results were below the ranges found in several studies which estimated the lead level of public water distribution system in USA was 5 mg/l.[16]Another review of lead levels in drinking-water in the USA found the geometric mean to be 2.8 µg/l.[17] Also The median level of lead in drinking-water samples collected in five Canadian cities was 2.0 µg/l.[18] In fish samples the mean Pb level was ranged from 0.313 to 1.523 mg/kg during winter season with the mean value of 0.918 mg/kg, and ranged from 0.133 to 0.873 mg/kg during summer season with the mean value of 0.503 mg/kg. These results were higher than the median short-term (0.05 µg/kg) and long-term intake for the whole population.[18,19]

Chromium: In water samples, the mean Cr level ranged from 0.018 to 0.020 mg/l during winter season with the mean of 0.019 mg/l, and ranged from 0.000 to 0.003 mg/l during summer season with the mean of 0.0015 mg/l. These results showed that the mean Cr concentration level found in all farms in both seasons are equal and below the minimum concentrations found in

several studies. The natural total chromium content of surface waters is approximately 0.5–2 mg/l, the dissolved chromium content is 0.02–0.3 mg/l, in rainwater is in the range 0.2–1 g/litre and in seawater it is 0.04–0.5 mg/l.[20]In surface waters in the USA, levels up to 84 mg/l have been found; in central Canada, surface water concentrations ranged from 0.2 to 44 mg/l, data from the National Water Quality Data Bank (NAQUADAT), Inland Waters Directorate, Environment Canada, 1985. In fish samples the mean Cr level was ranged from 0.367 to 3.436 mg/kg during winter season with the mean of 1.9015, and ranged from 0.736 to 2.580 mg/kg during summer season with the mean of 1.658 mg/kg. These results indicate lower levels than those in other food; ranging from 20 to 590 mg/kg.[15] The highest level of chromium were found in some kind of food including fish which reached<10 to 1300 mg/kg[20,21],which was higher than values found in this study. The US National Research Council (NRC) specify an Estimated Safe and Adequate Daily Dietary Intake (ESADDI) of 0.05 – 0.2 mg/day for adults and 0.01 – 0.04 mg/day for infants (0 – 0.5 years).[22]

Cadmium: In water samples, the mean Cd level ranged from 0.012 to 0.013 mg/l during winter season with the mean of 0.0125 mg/l, and ranged from 0.000 to 0.001 mg/l during summer season with the mean of 0.0005. These were very good results because they were below 1 mg/l as many several studies indicate.[23,24] In fish samples the mean Cd level was ranged from 0.027 to 0.039 mg/kg during winter season with the mean of 0.033 mg/kg, and ranged from 0.022 to 0.037 mg/kg during summer season with the mean of 0.031 mg/kg. These results were much lower than many several studies established to estimate the cadmium levels intake, which is (1 mg/l) in unpolluted natural water and (20 mg/kg) in fish.[24,25]

Zinc: In water samples, the mean Zn level ranged from 0.146 to 0.481 mg/l

during winter season with the mean value of 0.314 mg/l, and ranged from 0.008 to 0.013 mg/l during summer season with the mean value of 0.011. These results were lower than those of other studies which said that in natural surface waters, the concentration of zinc is usually below 10mg/l, and in ground waters is 10–40 mg/l. In fish samples, the mean Zn level ranged from 2.887 to 3.555 mg/kg during winter season with the mean value of 3.221 mg/kg, and ranged from 1.484 to 3.459 mg/kg during summer season with the mean value of 2.472 mg/kg. These results were lower than several studies said that Protein-rich foods, such as meat and marine organisms, contain high concentrations of zinc (10–50 mg/kg wet weight), whereas grains, vegetables, and fruit are low in zinc (usually <5 mg/kg), also these results were lower than the recommended daily intake for Zinc which is 5.6-10 mg/day for infants and children aged 2 months–11 years, 12.3–13.0 mg/day for children aged 12–19 years, and 8.8-14.4 mg/day for adults aged 20–50 years. Mean daily zinc intake from drinking-water is estimated to be < 0.2 mg/day.[26]

Accumulated Heavy Metals and MPL:

Copper:

Copper concentrations (Tables 1, 3, 5 and 6) were below MPL for both fish with the mean 3.448 mg/kg and water samples with the mean 0.139 mg/kg in all farms and during both seasons. Since the MPL for copper concentration in fish is 20 mg/kg,[27] while in water is 2 mg/kg.[28]This metal accumulates by several means, depending on environmental conditions and habits of species.[12] Copper is essential for animals and plants, as it takes part in enzyme formation and participates in respiratory processes, with accumulation levels varying widely among aquatic organisms. Variations in Cu concentration are related to levels of tolerance and toxicity symptom outbreaks, depending on species and period of passive accumulation.[29]

Lead:

Lead concentrations (Tables 1, 3, 5 and 6) were below MPL (1.5 mg/kg) for fish samples, except 2 samples from farm I during winter and 1 sample from farm II during summer.[27] Water samples were exceeded the MPL which is 0.01 mg/kg,[28] except for 1 sample of farm I and 2 samples from farm III during summer. Pb does not present beneficial or nutritional effects to organisms and is extremely toxic.[30] Overall it occurs in very low concentrations in the biota, even when there are high concentrations in the abiotic environment.[13] This metal is used in several industrial processes and is a common residue from gasoline combustion.[14] It ranks as the metal of largest diffusion through the atmosphere.[15]

Chromium:

Chromium concentrations (Table.1, 3, 5 and 6) were below MPL for both fish with the mean 1.836mg/kg and water samples with the mean 0.010 mg/kg in all farms and during both seasons. Since the MPL for copper concentration in fish and water is 0.5 mg/kg,[15] while in water is 0.05 mg/kg.[28]

Cadmium:

Cadmium concentrations (Tables 1, 3, 5 and 6) were below MPL (5 mg/kg) for fish samples with mean of 0.031 mg/kg. Water samples during winter were exceeded the MPL (0.003 mg/kg) with mean of 0.012 mg/kg, while they were below during summer with the mean of 0.000 mg/kg.

Zinc:

Zinc concentrations (Tables 1, 3, 5 and 6) were below MPL for both fish and water samples, except for 2 samples of farm I, 1 sample of farm II and 1 sample of farm III during winter season. Since the MPL for copper concentration in fish is 20 mg/kg,[27] while in water is 2 mg/kg.[28]

Heavy metal interaction:

The mean concentration of heavy metals in water samples of farm I could be arranged as Zn > Cu >Pb> Cr > Cd, while

in fish samples they could be arranged as Cu > Zn >Pb> Cr > Cd, we found that the mean Zn level in water samples was higher than the mean Cu level, while the contrary was found in fish samples. This may be due to the fact that low levels of copper in the perfusion medium resulted in an increased absorption of zinc, while medium and high copper levels resulted in decreased zinc absorption.(11)

The mean concentration of heavy metals in water samples of farm II could be arranged as Pb> Zn = Cu > Cr > Cd, while in fish samples they could be arranged as Cr > Zn > Cu >Pb> Cd. The mean concentration of Pb in water samples was higher than that of both Zn and Cu which were equal, but the opposite was found in fish samples; the mean Zn concentration was the highest followed by the mean Cu level then Pb level. This is possibly due to the fact that zinc decreasing the intestinal absorption of lead,(10)and Low levels of copper in the perfusion medium resulted in an increased absorption of zinc.(11)

The mean concentration of heavy metals in water samples of farmIIIcould be arranged as Cu > Zn >Pb> Cr > Cd, while in fish samples they could be arranged as Zn > Cu > Cr >Pb> Cd. It can be noticed that the mean Cu level was higher than the mean Zn level in the water samples, while the mean Zn levels was higher in fish samples. This is may be due to that the low levels of copper in the perfusion medium resulted in an increased absorption of zinc.(11)

The highest mean Cu, Zn, Cr, Pb and Cd levels in water samples were detected in winter season, which decreased during summer season. The highest mean Pb and Zn levels in fish samples were detected in winter season, which decreased during summer season. On the contrary, the mean Cu level was highest in summer season and lowest in winter season. There were no significant differences in the mean Cr and Cd

level between the two seasons (Tables 1 and 3).

B) Chemical composition:-

Results indicated that the range of ash shows no significant difference between the mean level of both seasons, which were 1.370% and 1.229% at winter season and summer season respectively (Table 2).Our results are in agreement with the results which found that edible fish muscle containing 1–2% ash.[31]

Results indicated that the range of moisture shows statistically significant difference between the mean level of both seasons for farm I only, were 71.290% and 73.928% at winter season and summer season respectively (Table 2).Generally, moisture levels were within the normal range of moisture.

Results indicated that the range of protein shows statistically significant difference between the mean levels of both seasons for farm I only. Protein concentration were 22.204% and 20.882% at winter season and summer season respectively, (Table 2). These results were higher than the results of Arin˜o, et al. (2003) who found that edible fish muscle contains 18–20% protein. [31]

Similarly, results indicated that the range of fat shows statistically significant difference between the mean level of both seasons of farm I only. Fat percentages were 4.970% and 3.961% at winter season and summer season respectively(Table 2). Edible fish muscle contains lipids varies from less than 1% to more than 20% (in high-fat finfish). [31]

C) Water quality

Results indicated that the range of salinity of water varied according to the site and the season of sampling. Salinity of farm ranged from 2.267ppm at winter season to 1.600 ppm at summer season with mean of 1.9335 ppm, which considered fresh. Salinity of farm II ranged from 4.000 ppm at winter season to 10.800 ppm at summer season with mean 7.4 ppm, which

considered brackish. Salinity of farm III ranged from 16.800 ppm at winter season to 15.467 ppm at summer season with mean 16.1335 ppm, which considered highly brackish (Table 4). Salinities observed in this study were fresh to brackish and fell within the range reported by Edokpayi *et al*.[32,33]

pH-values of the water samples were found to be on the alkaline side, it fluctuated between 7.4to 7.5during winter season, while it fluctuated between 7.6 to 8.7 during summer season, (Table4)It was reported that water with pH value of higher 6.5 is considered the best for fish production. pH levels were suitable for well-being of mullet fish.[32,33]

Surface water temperature is directly affected by solar radiation and varied between 21°C-26°C during winter and summer respectively, with a mean value of 23.5°C. However, the averages of water temperature were within the range considered for fish growth (Table4).These results were agreement with those obtained by Bakeer et al. They reported that ponds water is suitable for all chemical, physical and biological processes.[34]

CONCLUSION

From the above-mentioned results, we can conclude that in water samples, the highest heavy metals concentrations were detected during winter season with a big difference from summer season. It means that water during summer season was of better quality than during winter season.

Water samples of farm Iwere the lowest in the mean Pb level and was the highest in the mean Cu and Zn levels, while in fish samples, farm I was the highest in the mean Cu, Pb, and Zn levels and lowest in the mean Cr and Cu levels. Water samples of farm II was the lowest in the mean Cu and Zn levels, and highest in the mean Pb level, while fish samples of farm II was the highest in the mean Pb, Cr, Cd and Zn levels and was the lowest in the mean Cu level. Cu, Pb and Zn were detected in

high levels in farm III, while in fish samples Cu and Zn were found in high levels. In water samples, the mean Cr and Cd levels were not significantly different among the three farms.

RECOMMENDATIONS

Health education programs about general sources, exposure routes and health impacts of heavy metals and other chemicals are recommended. Establishment and strengthening of monitoring programs on environmental and health risk assessment. Control of discharge of heavy metals and other toxic chemicals to the environment is also recommended. Regular monitoring of aquatic food categories should be conducted, to avoid metal build up in the body, whose detrimental impact becomes apparent on humans only after several years of exposure. Further research studies on methods of removal of heavy metals from water and fish should be conducted.

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