Kafrelsheikh Vet. Med. J. Vol. 5 No. 2 (2007) (276-297)

EFFECT OF SALTING ON HEAVY METALS CONCENTRATIONS OF GREY MULLET *(Mugil cephalus)* FISH FROM DIFFERENT FARMS FISH IN KAFRELSHEIKH GOVERNORATE

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ABSTRACT

Concentrations of heavy metals (Cu, Zn, Ni, Cd, Mn, Cr, Pb and Fe) were measured in sediment, water, table salt and muscles of fresh and salted grey mullet (Mugil cephalus) fish from different fish farms in Kafrelsheikh Governorate. The results referred that sediments from all regions contained high levels of heavy metals compared to literature. On the other hand, higher concentrations of Cd and Pb were recorded in all water samples compared to ***FAO, (1984)****. Water contents of heavy metals may be affected by sediment contamination. Heavy metal concentrations of table salt were lower than the maximum permissible limits set by* ***EOSQC, (1993)*** *with the exception of Zn, Cd and Pb which were the highest. As for heavy metal concentrations in grey mullet fish before salting generally, fish samples from Al Hamoul had the lowest concentrations of Mn and Fe; while the samples from Sidi salem had the lowest concentrations of Zn, Cd and Pb. The lowest concentrations of Cu and Ni was found in samples from Motobes; while Cr was the lowest in samples from El Reyad. But, these values are higher than the maximum permissible limits set by* ***FAO/WHO (1989), EOSQC (1993), USFDA (1993)*** *and* ***EC (2001)****. After salting process for 4 weeks, the data reflected that, Cu, Cd, Mn, Cr and Pb decreased as a function of salting process. While, Zn, Ni and Fe increased as a function of salting process. These increment may be due to metal contamination of table salt.*

Keywords: Grey mullet (*Mugil cephalus*); heavy metals; salting; sediment and water.

INTRODUCTION

Fish are a major part of human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish ***(Kucuksezgin et al., 2001).***

Metals can be taken up by fish from water, food, sediments, and suspended particulate material ***(Hardersen and Wratten, 1998).***

However, the presence of a given metal at high concentrations in water or sediments does not involve direct toxicological risk to fish, especially in the absence of significant bioaccumulation. It is known that bioaccumulation is to a large extent mediated by abiotic and biotic factors that influence metal uptake ***(Rajotte et al., 2003).***

Heavy metals represent chemical residues which have a major role in human health. These elements are cumulative poisons causing health injury through progressive and irreversible accumulation in the body as a result of ingestion of reported small amounts ***(Alberti and Fidanz, 2002).***

Metal pollution can result from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products ***(Dawson and Macklin, 1998).***

Fish farms are the main source of grey mullet fish production in Egypt. Salted grey mullet (Feseekh) are one of the preferable forms of fish eaten in Egypt and consumed in a large scale.

The objective of our study was to evaluate the effect of salting of grey mullet from four different fish farms in Kafrelsheikh Governorate on heavy metals pollution by: (i) determining heavy metal concentrations in water and tissues of fish, (ii) comparing metal concentrations in fish muscle before and after salting.

MATERIALS AND METHODS

MATERIALS:

Fish samples:

Grey mullet *(Mugil cephalus*) fish samples were collected from four fish farms at four different regions in Kafrelsheikh governorate at summer 2007. These regions were El Reyad, Sidi salem, Motobes and Al Hamoul. These samples were brought to the laboratory on the same day.

Water samples:

Water samples for metal analysis were taken from the previously fish farms at 50 cm depth. Water samples were collected in polyethylene bags (washed with detergent, then with distilled water, and brought to the laboratory on the same day for heavy metals determination.

Sediment samples:

Five sediment samples from different parts were also taken from the same fish farms. The collected samples were air dried, ground in a mortar, sifted through a fine sieve and packed in polyethylene bags in quantities of 50 gm and then stored at -20 ^{o}C till subsequent digestion and analysis ***(Saydam and Salihoglu, 1991)*.**

Salt samples:

Table salt from El Nassr Company are used in salting process and purchased from local market.

METHODS:

Sample preparation:

Fish samples (ten fishes of grey mullet at length from 28 to 30 cm and 250 to 300 g in weight) were washed with distilled water to remove slime and mud, dried on filter paper. Samples from fish muscles were taken from each fish for moisture determination ***(A. O. A. C., 2000)*** and heavy metals determination on dry basis. While the other's fish samples were salted ***(Mendil and Uluozlu, 2007).***

Salting process:

About 5 fishes of each treatment were sun fermented for 6 hrs., and then salted by using dry (Kench) method of salting at a rate of 4 : 1 (w/w) fish : salt (the same process commonly used on a commercial scale in Egypt) for 4 weeks at room temperature.

Heavy metals determination:

Water samples:

One- liter water was gently evaporated over water path till dryness, dissolved in 5 ml concentrated HNO_3 and few drops of H_2O_2 were added to complete digestion. The dried residue was dissolved in 1 ml HNO_3 and the volume is made to 50 ml for heavy metals measurement as described by ***Kopp and Korner (1967)***. The tested heavy metals were measured by Perkin Elmer atomic absorption spectrophotometer (AAS) Model 2380.

Fish, table salt and sediment samples:

The digestion of fish muscles, table salt and sediment samples were as carried out by wet ashing using nitric acid perchloric acid mixtures by Aqua regia method according to ***Cottenie et al. (1982)***. Heavy metals were determined as the method outlined by ***Kapito, (1973)***. This method has been shown to be 98- 100% efficient for recovering the metals of interest from biological tissues ***(Robert, 1977).*** Heavy metals were analyzed using atomic absorption spectrophotometer (AAS) (Perkin Elmer, Model 2180) in the aqueous solutions.

Statistical analysis:

The obtained data were statistically analyzed using General Linear Models Procedure Adapted by Statistical Package for the Social Sciences ***(SPSS, 1997).***

RESULTS AND DISCUSSIONS

Sediment:

The mean concentrations of metals measured in sediment samples are presented in Table (1). The highest concentration levels of Cu and Fe were found in the sediment from Sidi salem. While, the highest concentration levels of Zn and Ni were found in the sediment from El Reyad; it recorded 8.072 and 51.60 mg/kg dry sediment). High concentrations of Cd and Cr were found in the sediment from Al Hamoul comparable to those obtained in other areas. On the other hand, Pb and Mn levels in sediment from Motobes were the highest among other areas. It recorded 4.46 and 186.17 mg/kg dry sediment. This variation in heavy metal concentrations in the sediment from different areas may be due to the differences in the sources of metal pollution and physical- chemical conditions favoring sediment contamination.The degree of environmental contamination that is may be attributed to the use of poultry droppings in fertilization of fish farms ***(Hardy et al., 1984).***

Table (1): Mean concentrations (mg/kg dry mass) of heavy metals in sediment from selected farms fish.

Sample regions	Heavy metal concentrations (mg/kg)							
	Cu	Zn	Ni	Cd	Mn	Cr	Pb	Fe
Al Hamoul	5.002c	7.371b	41.52c	2.482a	162.91d	8.642a	4.23b	1718.0c
Sidi Salem	6.118a	6.023d	43.15b	1.913c	179.32b	6.027c	4.23b	2015.0a
Motobes	4.460d	6.595c	35.47d	2.125b	186.17a	5.142d	4.46a	1823.0b
El Reyad	5.316b	8.072a	51.60a	1.937c	173.29c	7.112b	3.16c	1596.0d

Means of treatments having the same case letter(s) within a column are not significantly different at ($p > 0.05$).

In sediments most heavy metals are bound to the surface of organic components or to large inorganic substances ***(Lietz and Galling, 1989).*** Heavy metals content of sediments is a good indicator of the availability of heavy metals content to fish in water sources ***(Bradley and Morris, 1986)*****.**

The sediments of water sources might act as sinks and possible sources of pollution because adherent metals conditions such as pH and the presence of chelator. Organic matter plays an important role in binding heavy metals in sediments of water sources ***(Schintu et al., 1991)*.**

Water:

Table (2) shows heavy metal concentrations in water from the previously fish farms. The results indicated that, heavy metal concentrations in the sediments reflected its contents in water. As with the sediment, the highest mean levels of Cu and Fe were found in the water from Sidi salem, it recorded 0.475 and 28.15 µg/L; respectively.

No significant differences in Zn and Pb concentrations were found in water fish farms. But, Ni concentration in water from El Reyad was found to be the highest among all other water sources. The highest concentration levels of Cd and Cr were found in the water from Al Hamoul compared to obtained in other areas. It recorded 0.425 and 0.894.

Table (2): Mean concentrations (µg/L) of heavy metals in selected farms fish water.

Sample regions	**Heavy metal concentrations (µg/L)**							
	Cu	**Zn**	**Ni**	**Cd**	**Mn**	**Cr**	**Pb**	**Fe**
Al Hamoul	0.317c	0.307ns	3.15c	0.425a	27.19d	0.894a	0.445ns	18.75d
Sidi Salem	0.475a	0.273	3.00d	0.219c	37.57b	0.564c	0.436	28.15a
Motobes	0.288d	0.265	4.02b	0.311b	39.18a	0.557c	0.432	25.82b
El Reyad	0.382b	0.375	5.11a	0.285d	30.05c	0.653b	0.448	20.49c
FAO, (1984)	1.0	5.0	-	0.005	-	-	0.05	-

Means of treatments having the same case letter (s) within a column are not significantly different at ($p > 0.05$).

µg/L of water. The highest concentrations of Mn were found in the water from Motobes which recorded 39.18 µg/L. on the hand, no significant differences in Pb concentrations were found among the different water sources.

The agricultural drainage water which recycled for the irrigation of fish farms contains the washed discharges of insecticides, herbicides and other effluents of organic and inorganic fertilizers which may exaggerate the presence of heavy metals in the aquatic environment and adversely reflected on fish life ***(Kirby et al., 2001).***

In aquatic systems, metals are transported either in solution or on the surface of suspended sediments ***(Dawson and Macklin, 1998).*** Due to their strong affinity for particles ***(Luorna, 1990)***, metals tend to be accumulated by suspended matter or trapped immediately by bottom sediments ***(Dauvalter, 1998)***. These metals may be in sediment through indirect discharge or from atmospheric deposition at the power plant.

Heavy metal concentrations of table salt:

The table salt used in salting process were analyzed for heavy metals determination and the results are tabulated in a table (3). The data referred that heavy metal concentrations of table salt were lower than the

Table (3): Mean values of heavy metal concentrations (mg/kg) in the table salt used in salting process.

Sample	Heavy metal concentrations (mg/kg)							
	Cu	**Zn**	**Ni**	**Cd**	**Mn**	**Cr**	**Pb**	**Fe**
Table salt	0.51	73.18	67.43	0.25	0.31	3.18	1.75	25.72
*EOSQC, (1993)	20.0	50.0	-	0.1	-	5.5	1.0	-
Max. Residues Limits	**30.0	**50.0	***80.0	#1.0	-	***13.0	**0.5	-

*Egyptian Organization for Standardization and Quality control. Values are in ppm = mg/kg.

**FAO/WHO, (1989). ***USFDA, (1993). #EC, (2001), values are in mg/kg.

permissible limits set by ***EOSQC, (1993)*** with the exception of Zn, Cd and Pb. Also, lower than the permissible limits set by ***(FAO/WHO, 1989; USFDA, 1993 and EC, 2001)*** with the exception of Zn and Pb was the highest.

Fish samples before salting:

The present study found that the metal accumulation in experimental fish was strongly related to the sediment exposure. The uptake of sediment- associated contaminants by fish may occur through three pathways; (1) fine particles re-suspended to water column which is uptaken by filter-feeders via gill and digestive tract, (2) leaching of sedimentary contaminates to water which accumulated in fish body via respiration, (3) direct contact and consumption of the sediment by bottom- dwellers/mud- eaters via skin and intestine ***(Chen and Chen, 1999).***

Table (4) shows the mean concentrations of heavy metals in grey mullet fish from different fish farm in Kafrelsheikh Governorate. Generally,grey mullet fish from Sidi salem had the highest concentrations of Cu and Fe. It recorded about 4.20 and 21.00 mg/100g dry sample; respectively. While, the highest mean concentrations of Zn and Ni were found in fish from El Reyad. It reached 17.20 and 25.40 mg/100g dry sample; respectively. The highest mean concentrations of Cd and Cr were found in fish from Al Hamoul. It recorded about 1.26 and 28.60 mg/100g dry sample; respectively. while in Mn and Pb the highest concentrations were found in Motobes.

It is generally accepted that heavy metal uptake occurs mainly from water, food, and sediment (bottom feeders and burrowing animals). 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

Table (4): Mean values of heavy metal concentrations (mg/100g dry sample) in the muscles of fresh grey mullet fish samples.

Sample regions	Heavy metal concentrations (mg/100g dry)							
	Cu	Zn	Ni	Cd	Mn	Cr	Pb	Fe
Al Hamoul	2.20c	12.60b	6.40c	1.26a	0.40d	28.60a	37.20b	13.20d
Sidi Salem	4.20a	9.30d	11.00b	0.00d	4.12b	26.20b	27.20d	21.00a
Motobes	1.80d	9.80c	2.80d	0.82b	5.00a	23.00c	41.40a	18.80b
El Reyad	4.00b	17.20a	25.40a	0.58c	2.50c	3.80d	34.80c	14.2c
*EOSQC,(1993)	20.0	50.0	-	0.1	-	5.5	1.0	-
Max. Resid. Lim.	**30.0	**50.0	***80.0	#1.0	-	***13.0	**0.5	-

Means of treatments having the same case letter(s) within a column are not significantly different at ($p > 0.05$).

*Egyptian Organization for Standardization and Quality control. Values are in ppm = mg/kg.

**FAO/WHO, (1989). ***USFDA, (1993). #EC, (2001), values are in mg/kg.

Factors such as salinity, temperature, and interacting agents ***(Goyer, 1991; Canli and Furness, 1995)***. It is well known that heavy metals accumulated in substantially high levels can be very toxic for fish, especially for young and eggs which are very sensitive to pollution ***(Kalay and Erdem, 1995)*.**

The results referred that, mean Cu concentrations ranged from 1.80 to 4.20 mg/100g dry in grey mullet from Motobes and Sidi salem; respectively. These results are higher than that reported by ***Yilmaz, (2003)*** which found that Cu concentration in grey mullet muscles from Iskenderun Bay in Turkey were 1.45 µg/g wet weight. Also, our results are higher than that recorded by ***Khalifa, (2006),*** who found that copper residues in grey mullet from three fish farms in Kafrelsheikh ranged from 0.423 to 0.478 ppm in El Hamoul and El- Reyad; respectively.

The maximum permissible limit of copper according to the Egyptian Organization Standardization and Quality Control ***(EOSQC, 1993)*** was 20 ppm (2 mg/100g). While, the obtained data in Sidi salem, El Reyad and Al Hamoul are higher than those of the maximum permissible limit.

Whereas, copper is known to be essential at low level but it is toxic at high level. The lethal doe is about 100 ppm ***(Clark, 1989)***. It is important in formation of erythrocytes, development of bones, central nervous system and connective tissues. Acute exposure to copper causes hypotention, haemolytic anaemia and cardiovascular collapse, while chronic exposure resulted in Jaundice in human ***(Gossel and Bricker, 1990).***

Iron concentrations varied between 13.20 mg/100g dry sample in samples from Al Hamoul to 21.00 mg/100g dry sample in Sidi salem. These results are higher than that reported by ***Yilmaz, (2003)*** which were 70.23 µg/g wet sample in grey mullet from Turkey.

Zinc is an essential trace element for both animals and humans. The recommended daily allowance is 10 mg/day in growing children and 15 mg/day for adults ***(NAS- NRC, 1974)***. A deficiency of zinc is marked by retarded growth, loss of taste and hypogonadism, leading to decreased fertility. Zinc toxicity is rare but, at concentrations in water up to 40 mg/kg, may induce toxicity, characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea ***(NAS- NRC, 1974)***. Zinc appears to have a protective effect against the toxicities of both cadmium ***(Calabrese et al., 1985)*** and Lead ***(Sanstead, 1976)*****.** The zinc content in the samples ranged from 9.30 to 17.20 mg/100g dry sample. These results are higher than that reported by ***Khalifa, (2006)*** which ranged between 1.039 to 1.202 ppm. Also, our results are higher than that recorded by ***Yilmaz, (2003)*** which recorded 3.823 mg/100 g wet weight. Also, our results are higher than the maximum residues limits set by ***FAO/WHO, (1989)*** and ***EOSQC, (1993)*** which were 50 ppm (5.0 mg/100g).

The major source of nickel for humans is food and uptake from natural sources, as well as food processing ***(NAS- NRC, 1975)*****.** The normal range of oral intake of nickel for humans is 300 – 600 µg/day.

Nickel concentrations varied significantly among fish farm regions in fish samples. Higher concentrations of nickel were observed in the samples from El Reyad which recorded 25.40 mg/100g dry sample. The maximum residues limit (MRL) for nickel is 70 – 80 mg/kg ***(USFDA, 1993).***

Cadmium is known to induce chronic renal disease due to the fact that urinary elimination is the main route of excretion ***(Madden and Fowler, 2000)***. Also, a well known carcinogenic and immunotoxic metal commonly found in industrial effluent ***(Kim and Sharma, 2004).*** Moreover cadmium poisoning may result in a case called Itai- Itai or ouch- ouch disease which characterized by sever pain, soft bones and death may occur as a result of renal failure ***(Peter, 1993)***. In ***(1998)*** the **joint *FAO/WHO Expert Committee of Food Additive*** (JECFA) established a provisional tolerate weekly intake (PTWI) for cadmium 7 µg/kg BWT. Applicable to adult as well as infant and children. The mean concentration of cadmium in samples from Al Hamoul was the highest among all of the used samples; it recorded 1.26 mg/100g dry sample. While not detected in samples from Sidi salem. The obtained results were higher than that reported by ***Saleh, (2004)*** and ***Khalifa, (2006)***. Also, it was evident that, the mean concentration of cadmium detected in samples from Al Hamoul, Motobes and El Reyad exceeded the permissible limit (0.1 ppm = 0.01 mg/100g) set by ***EOSQC, (1993)*** and also higher than the maximum residues limits set by ***EC, (2001).***

Manganese is an essential element for both animals and plants and deficiencies result in severe skeletal and reproductive abnormalities in mammals. It is widely distributed throughout the body with little variation and does not accumulate with age. Total daily intake varies from 2.5 to 7 mg ***(NAS- NRC, 1977)***. Manganese was detected in all the samples and the concentration ranged from 0.40 in Al Hamoul to 5.00 mg/100g dry sample in Motobes.

Chromium is an essential trace element ***(Mertz, 1969)*** and the biologically usable form of chromium plays an essential role in glucose metabolism. It has been estimated that the average human requires nearly 1 µg/day. Deficiency of chromium results in impaired growth and disturbances in glucose, lipid, and protein metabolism ***(Calabrese et al., 1985)***. Water contributes a major share of chromium in humans ***(Underwood, 1977).*** Chromium was detected in almost all the samples and the highest concentration (28.60 mg/100 g dry sample) was detected in samples from Al Hamoul. The presence of chromium in all examined samples with this levels is almost the result of human activity, reflecting pollution from industrial activities and/or sewage wastes ***(Perlmutter and Lieber, 1970).*** Chromium in food is low and present in two forms trivalent and hexavalent. Its interesting to mention that hexavalent form is the most toxic one ***(Lars, 2004).*** The lethal oral dose of soluble chromate was considered to be 50 mg/kg BWT ***(RTECS, 1978).*** The results found in our present study revealed that, all samples had high levels of chromium more than the safe levels (5.5 ppm = 0.55 mg/100g) as indicated by ***EOSQC (1993)***. Also, higher than the maximum residues limits set by ***USFDA, (1993)*** which were 13 ppm (1.3 mg/100g)**.** The results are higher than that reported by ***Yilmaz, (2003), Saleh, (2004)*** and ***Khalifa, (2006).***

Lead is recognized as a toxic substances which accumulated inside the body due to its low rate of elimination, it causes renal failure and liver damage in humans ***(Luckey and Venugopal, 1977)***. It is affect on reproduction in men and women. In men it is affect on male gonads resulting in abnormalities in sperms, impotence and sterility ***(Timbrell, 1982)***, while in women it is associated with abnormal ovarian cycles and menstrual disorder, spontaneous abortion, stillbirth and fetal macroceph-ally ***(Needleman et al., 1984)***. So that special attention should be taken to avoid pregnant women from lead exposure because up to 50% of child's blood level can be absorbed through the mother's body ***(Zadorozhnaja et al., 2000)***. Also, it is known to cause encephalopathy in children ***(Carl, 1991; Baghurst et al., 1992; Lidsky and Schneider, 2003)***. Mean concentration of lead varied from 27.20 in Sidi salem to 41.40 mg/100g dry sample in samples from Motobes. These values are higher than those reported by ***Wong et al. (2001)*** and ***Saleh, (2004)*** and ***Khalifa, (2006)***. Also, these values are higher than the permissible limit (1.0 ppm = 0.1 mg/100g) set by ***EOSQC, (1993)*.** The joint provisional tolerate weekly intake (PTWO) lead 50 µg/kg BWT applicable to adult only, noted that any increase in the amount of lead derived from drinking water or inhaled from atmosphere will reduce the amount can be tolerated in food ***(WHO, 1992)***. As special concern for infants and children (JECFA) reduce the (PTWI) to 25 µg/kg BWT from all sources.

The permissible limits proposed by the FAO, WHO established the following maximum levels for some heavy metals which consumption is not permitted: 0.1 µg/g for Cd, 5 µg/g for Cu, 50 µg/g for Zn and 0.5 µg/g for Pb ***(FAO/WHO, 1989; WHO, 1993).***

Generally, fish samples from Al Hamoul had the lowest concentrations of Mn and Fe; while the samples from Sidi salem had the lowest concentrations of Zn, Cd and Pb. The lowest concentrations of Cu and Ni was found in samples from Motobes; while Cr was the lowest in samples from El Reyad.

Effect of salting on heavy metal concentrations:

The results in Table (5) shows heavy metal concentrations in grey mullet fish (Feseekh) after salting. The data reflected that, Cu, Cd, Mn, Cr and Pb decreased as a function of salting process. While, Zn, Ni and Fe increased as a function of salting process. These decrement may be due to the loss of water contents and its contents of soluble substances. On contrary, some heavy metals increased as a function of salting process such as Zn, Ni and Fe; it may be due to the salt contamination by these metals with high concentrations.

It should be observed also from Table (5) that Cu, Zn and Ni were lower than the maximum permissible values set by ***(FAO/WHO, 1989*** and ***USFDA, 1993)***. Salted fish from Sidi salem had not cadmium; while Cd contents from other regions were higher than the values permissible by ***EOSQC, (1993)*****;** but lower than the maximum permissible limits set by ***(EC, 2001)***. Salted fish from Al Hamoul had not Cr contents; while from El Reyad contained Cr lower than the permissible by ***EOSQC, (1993)*****.** Cr contents from Sidi salem and Motobes samples were higher than the permissible limits set by ***EOSQC, (1993)***. While the samples from Sidi salem were higher than that accepted by ***(USFDA, 1993)*** but, from Motobes lower than ***(USFDA, 1993)*****.**

Table (5): Mean values of heavy metal concentrations (mg/100g) in the muscles of salted grey mullet fish samples.

Sample regions	**Heavy metal concentrations (mg/100g)**							
	Cu	**Zn**	**Ni**	**Cd**	**Mn**	**Cr**	**Pb**	**Fe**
Al Hamoul	1.60b	19.00c	31.60b	0.32a	0.22bc	0.00d	0.00c	24.80b
Sidi Salem	0.20d	17.80d	37.80a	0.00	0.12c	17.80a	15.00b	11.60d
Motobes	0.40c	21.40b	4.80d	0.20b	0.36b	11.80b	15.60a	18.60c
El Reyad	2.60a	21.60a	24.20c	0.22b	0.74a	2.40c	0.00c	43.40a
*EOSQC, (1993)	20.0	50.0	-	0.1	-	5.5	1.0	-
Max. Resid. Lim.	**30.0	**50.0	***80.0	#1.0	-	***13.0	**0.5	-

Means of treatments having the same case letter(s) within a column are not significantly different at ($p > 0.05$).

*Egyptian Organization for Standardization and Quality control. Values are in ppm = mg/kg.

**FAO/WHO, (1989). ***USFDA, (1993). #EC, (2001), values are in mg/kg.

Lead contents not detected in salted fish from Al Hamoul and El Reyad; but the samples from Sidi salem and Motobes had lead contents higher than that permitted by ***EOSQC, (1993)*** and ***FAO/WHO, (1989)*.** No information were published about the maximum permissible limits for Mn and Fe in ***EOSQC, (1993)*** and ***(FAO/WHO, 1989; USFDA, 1993 and EC, 2001)*.**

CONCLUSION:

Generally and from the previous results we concluded that sediments and water from all regions contained high levels of heavy metals. These contents in sediments reflected its contents in water. Table salt contained heavy metals with high levels. Zn, Cd and Pb concentrations were higher than the permissible limits set by ***EOSQC, (1993)***. Salting process reduced some heavy metals in grey mullet fish such as Cu, Cd, Mn, Cr and Pb. While some heavy metals are increased as a function of salting process such as Zn, Ni and Fe; it may be due to the high contamination of table salt with these metals. Also, we can say although most heavy metals are decreased concurrent with salting process but still higher than the maximum permissible limits set by ***(FAO/WHO, 1989; USFDA, 1993 and EC, 2001)*.** So it is recommended that sanitary protection of water against heavy metals pollution including hygienic disposal of agricultural discharge, sewage and industrial effluent. Also, avoidance of uses poultry droppings in fertilization of fish farms.

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تأثير التمليح على تركيز المعادن الثقيلة في اسماك البوري
من مزارع مختلفة في محافظة كفر الشيخ

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تمت هذه الدراسة على اسماك البوري المأخوذ من 4 مزارع في محافظة كفرالشيخ وهى الحامول ، سيدي سالم ، مطوبس والرياض في صيف 2007م. حيث تم في هذه الدراسة تقدير المعادن الثقيلة مثل النحاس والزنك والنيكل والكادميوم والمنجنيز والكروم والرصاص والحديد في كل من رواسب ومياه المزرعة وعينات السمك قبل التمليح وكذلك ملح الطعام المستخدم في عملية التمليح. أيضا تم تقدير

المعادن الثقيلة في اسماك البوري بعد التمليح لمعرفة مدى تأثير التمليح على متبقيات المعادن الثقيلة في البوري المملح. حيث أظهرت النتائج أن:

(1) احتوت جميع عينات الرواسب على تركيزات مرتفعة من المعادن الثقيلة أعلى من مثيلاتها في الدراسات السابقة.

(2) احتوت عينات مياه المزارع المختلفة على تركيزات عالية من الرصاص والكادميوم مقارنة بالحدود المسموح بها من ***FAO, (1984)*** . بينما باقي العناصر كانت في الحدود المسموح بها.

(3) احتوى الملح المستخدم في تمليح السمك على كمية من المعادن الثقيلة في الحدود المسموح بها ما عدا الزنك والكادميوم والرصاص كانوا أعلى من الحدود المسموح بها.

(4) بالنسبة لكمية المعادن الثقيلة في اسماك البوري قبل التمليح أظهرت النتائج أن عينات السمك المأخوذة من الحامول احتوت على اقل تركيزات من المنجنيز والحديد. بينما العينات المأخوذة من سيدي سالم احتوت على اقل التركيزات من الزنك والكادميوم والرصاص. كذلك العينات المأخوذة من مطوبس احتوت على اقل التركيزات من النحاس والنيكل. بينما العينات المأخوذة من الرياض احتوت على اقل التركيزات من الكروم. وعموما فان كل هذه التركيزات كانت أعلى من الحدود المسموح بها محليا وعالميا".

(5) أدت عملية التمليح لمدة 4 أسابيع إلى خفض تركيزات معظم المعادن الثقيلة مثل النحاس والكادميوم والمنحنيز والكروم والرصاص ، بينما زادت تركيزات كل من الزنك والنيكل والحديد وربما يكون ذلك راجع إلى تلوث الملح المستخدم في عملية التمليح بهذه المعادن بتركيزات عالية.