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As, Cd, Cu, Pb, Hg, and Zn in Fish from the Alexandria Region, Egypt

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Metals such as mercury, cadmium, arsenic, and copper tend to accumulate in bottom sediments from which they may be released by various processes of remobilization, and - in changing form - can move up the food chain, thereby reaching man where they could produce chronic and acute ailments. Investigations of metals in fish are an important aspect of environmental pollution control because human activities progressively increase the concentrations of heavy metal in the aquatic system. The study of fish muscle tissue is one of the means for investigating the amount of heavy metals reaching man by the food chain and has therefore been investigated more than other organs.

In Alexandria (Fig 1), Pollutant metals may be derived from anthropogenic activities, especially from industrial and agricultural wastes from several major drains. Abu Qir Bay is characterized by fish productivity, growing industrial, and naval activities. Idku and Maryut lakes are characterized by fish productivity. All of them receives wastewaters from several drains. The purpose of this study was to determine metal concentrations in fish samples collected from Abu Qir Bay, Idku lake and Maryut lake.

MATERIALS AND METHODS

Four species, *Pagellus erythrinus*, *Siganus rivulatus*, *Sphyraena sphyraena*, and *Trigla hirundo*, from Abu Qir Bay and Tilapia species (*Tilapia nilotica* and *Tilapia zillii*) from Idku and Maryut lakes (Fig 1) were collected from local commercial fishermen in September 1985 and the total length and weight of each fish was determined. Tow sampling locations from Maryut lake namely El-Qalaa drain and Forn El-Gieraia were selected. Edible portions of fish, which are skin-off fillets, were cut into small pieces, then blended. In case of fish samples from Abu Qir Bay,

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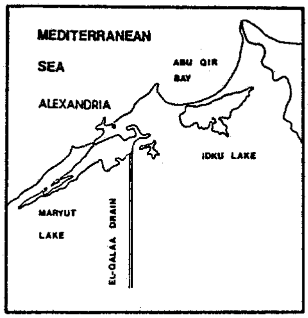

Fig. 1: Map of the Alexandria Region

additional liver samples were also dissected and were then blended. Deionized water was added as needed to facilitate homogenization of each sample. the homogenates were frozen at -30° C in a freeze dryer.Samples were lyophilized and stored.

Cadmium, copper, lead, mercury, and zinc - Aliquotes (0.2 g) of lyophilized samples were placed in digestor Teflon tubes. 1 ml of concentrated HNO_3 was added to each tube, and sample-acid mixture was held at room temperature for 1 hr to reduce foaming when heat was applied. Samples were heated on an aluminum block digestor at 170° C for 5 hrs. After digestion, 1 ml 1% HCl was added, and samples heated to dryness. The residue was dissolved with 3 ml 0.25 M HNO_3. Arsenic - The previous procedure was performed with the exception that samples were heated to dryness without 1 % HCl addition, and the temperature did not exceed 100° C.

Cadmium, copper, and lead were measured with a Perkin-Elmer (P-E) Model 4000 atomic absorption spectrophotometer equipped with an HGA-500 graphite furnace and an AS-1 auto sampler. Correction for chemical and matrix intereferences was performed by standard addition procedure on each digestate. Zinc was determined by flame absorption with a Perkin-Elmer (P-E) Model 373 with AS-3 auto sampler. Mercury was determined by a flameless cold vapor technique, Mercury/Hydride System MHS-20 , Amalgam attachement. Arsenic was determined by atomic absorption analysis after arsenic was formed with a P-E MHS-20 hydride generation system. The accuracy of this method has been determined by spiking samples with known amounts of As, Cd, Cu, Hg, Pb, and Zn with recoveries of 92-96 %. The determinations were made in duplicate.

RESULTS AND DISCUSSION

Arsenic concentrations in muscle tissue of fish (Table 1) ranged from 0.97 to 10.5 ppm from Abu Qir Bay and in muscle tissue of Tilapia species (Table 2) ranged from 0.11 to 0.18 ppm. The highest concentrations of arsenic was found in muscle tissue of *Sphyraena sphyraena* from Abu Qir Bay, whereas levels of arsenic were the same in muscle tissue of Tilapia species from Idku and Maryut lakes.

was found in muscle tissue of *Sphyraena sphyraena* from Abu Qir Bay, whereas levels of arsenic were the same in muscle tissue of Tilapia species from Idku and Maryut lakes. Arsenic is not a threat to fisheries resources , except in case of extreme pollution (Moor and Ramamoorthy, 1984). Marine species maintain relatively high burdens of arsenic. Concentrations in black marlin from Australian waters ranged from 0.1 to 2.75 mg/kg, while several species inhabiting the Middle Atlantic Bight had maximum residues of 21 mg/kg (Greig *et al.*, 1976; Mackay *et al.*, 1975).

Table 3 summarizes concentrations of arsenic in fish livers from Abu Qir Bay. The present results indicate that arsenic levels in liver are not consistently higher than those in muscle. The ratio of arsenic in the corresponding values for *Trigla hirundo*, *Siganus rivulatus* were 1.25:1, and 4.4:1, respectively. Mackay *et al.* 1975, reported that the ratio of arsenic in the liver:muscle of black marlin was 1.7:1, while Bohn and Fallis (1978) showed that the values for shorthorn scuplin, and Arctic char were 2:1 and 1.4:1, respectively. By contrast, the liver:muscle ratio in *Sphyraena sphyraena* was 1:2. Similarly, the ratio of arsenic in the liver : muscle in Arctic cod was 0.1:1 (Bohn and McElroy, 1976) and 0.2 - 0.5:1 in various deep sea species (Greig *et al.*, 1976) . Hence monitoring programs for arsenic should involve the analysis of a variety of tissues in fish.

The concentrations of cadmium found in both muscle tissue (Table 1) and liver (Table 3) of fish from Abu Qir Bay and in muscle tissue (Table 2) of Tilapia species from Idku and Maryut lakes were small compared with the US National Academy of Sciences (1972) health standards 0.5 mg/kg. The highest cadmium value (0.108 mg/kg) was in the liver of *siganus rivulatus* from Abu Qir Bay. So far in many countries there are no tolerance limits for such toxic metals as cadmium and lead in the edible parts of fresh marine fish (Falandysz, 1985). In Australia, the recommendations of the National Health and Medical Research Council specify that the concentrations of cadmium or lead in the edible parts of fish should not exceed 2.0 mg/kg (Bebbington *et al.*, 1977). Of all the fish samples examined none contained cadmium concentrations in their muscles or livers above 2.0 mg/kg. The maximum concentrations found were 0.023 mg/kg in muscle tissue and 0.108 mg/kg in liver.

The average concentrations of copper in the fish muscle samples are shown in Tables 1 & 2. The concentrations of copper found in fish of the same species, but taken in different regions revealed some areal differences (Table 2). The levels of copper in other species of fish muscle samples taken from Abu Qir Bay showed a moderate range values *i.e.* from 6.9 to 10.2 mg/kg dry weight (Table 1). Residues in livers of *Pagellus*, *Sphyraena*, *Trigla*, and *Siganus* from Abu Qir Bay were 2-4 times greater than those in muscle tissues. It was noted that *Sphyraena sphyraena* contained the highest level of copper (31.8 mg/kg) in its liver, whereas *Trigla hirundo* contained the highest level of copper (10.2 mg/kg) in its muscle tissues. Although residues in muscle tissue are generally low,and frequently decline with age and size of fish (Moore and Ramamoorthy, 1984). McFarlane and Franzin (1980) demonstrated a consistent positive correlation between copper in pike livers and fish age. This implies liver analysis provides a better analysis of the health status of fish populations than muscle analysis.

Mercury residues were detected in all samples of fish collected (Table 1-3). The US National Academy of Science (1972) recommends that to protect fish and predatory aquatic organisms, total mercury burdens in these organisms should not exceed 0.5 mg/kg net weight. In the present study, levels of mercury above 0.5 mg/kg were detected in *Pagellus* (0.62 mg/kg), and *Sphyraena* (0.65 mg/kg) from Abu Qir Bay. The WHO recommended 0.35 mg mercury as a provisional tolerable weekly intake of an adult (70 kg body weight). Consumption of more than 2-3 kg(wet weight) *Pagellus* or *Sphyraena* from Abu Qir Bay could exceed these limits. The level of mercury residues are generally low in muscle tissue of Tilapia species from Idku and Maryut lakes.

The results indicate that total residues are usually slightly higher in organs than muscle tissue. For example the liver:muscle ratio for mercury in *Trigla hirundo* and *Siganus rivulatus* were 5.2:1, and 5.6:1, respectively. A study by Mackay *et al.* (1975) showed that the ratio of mercury in the liver:muscle in black marlin collected from Australia was 1.4:1. Average concentrations in the muscle, liver, and kidney of several species from the Mediterranean were 0.30, 0.41, and 0.76 mg/kg wet weight, respectively (Buggiani and Vannucchi, 1980). By contrast, the liver:muscle ratio in *Sphyraena sphyraena*, and *Pagellus erythrinus* were 1:4.6, and 1:2.6, respectively. As also noted in perch inhabiting two Swiss lakes had muscle residues ranging from 0.06 to 0.21 mg/kg, compared with 0.03 - 0.14 mg/kg for liver (Hegi and Geiger, 1979).

Lead residues were present in all samples in the present study (Tables 1-3). From Abu Qir Bay, only one of four species, *Siganus rivulatus*, had lead residues in muscle tissue exceeding 0.5 mg/kg. Walsh *et al.* (1977) reported lead levels of 1.0 mg/kg and 1.4 mg/kg in fish from the Columbia River at Grand Coulee, Wash., and Monoa Stream, Hawaii, respectively. Lead residues in muscle tissue are usually lower than those in organs (Table 1 & 3). This may be explained by the relatively low rate of binding to SH groups; in addition the low solubility of salts restricts movement across cell membranes (Moore and Ramamoorsthy, 1984). The concentrations of lead found in all muscle samples are lower compared with the maximum level of 1.0 mg/kg lead measured in the edible parts of fish in Sweden (Swedish food regulations, 1983).

The concentrations of zinc have been determined in both muscle tissue (Table 1) and liver samples (Table 3) of four fish species from Abu Qir Bay, and in muscle tissue (Table 2) of Tilapia species from Idku and Maryut lakes. Zinc in muscle tissue from 15 species of omnivorous and carnivorous fish collected from industrial areas of the lower Great Lakes were 16-82 and 3-0 mg/kg wet weight, respectively (Brown and Chow, 1977). Similarly, yellow perch, bluegill, and black crappie inhabiting recreational and industrial zone rivers in the USA had average muscle burdens of 106, 108, and 103, and 100, 109, and 101 mg/kg dry weight, respectively (Vinikour *et al.*, 1980;Adams *et al.*, 1980). Like copper, the concentrations of zinc found in muscle tissue of fish of the same species, but taken in different regions, showed some areal differences (Table 2). As with invertebrates, zinc residues are greatest in specific organs of all species. The ratio of zinc in the liver:muscle in *Pagellus*, *Sphyraena*, *Trigla*, and *Siganus* from Abu Qir Bay are 4.7:1, 4.3:1, 2.2:1, and 2.3 :1, respectively. Mackay *et al.* (1975) reported that the ratio of zinc in the liver:muscle of black marlin was 5.5 :1.

In conclusion production and disposal often results in transfer of trace metals to the aquatic environment and hence the food chain. Monitoring the contamination of fish was undertaken for assessment of the environmental pollution of the Alexandria region. We observed some interspecies variation in the concentration of essential and toxic chemicals, but only mercury in two species, *pagellus erythrinus*, and *Sphyraena sphyraena* could exceed the recommended limits for human intake, if more than 3 kg are consumed per week. The interspecies variation indicates the importance of monitoring different species and the analysis of muscle tissue as well as other organ tissue in environmental toxicology. A continuation of the monitoring program is necessary to assess the effects of anthropogenic activity, mainly pollution, and for health survey of important pathways of the food chain. Apparently consumption of fish from the Alexandria region does not pose a health hazard; but protection of the aquatic environment is warranted to preserve this important part of the traditional diet.

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Table 1. Concentrations of arsenic, cadmium, copper, lead, mercury, and zinc in muscle tissue of fish from Abu Qir Bay, September 1985

Species	N [a]	Average Size		Metal Concentrations mg/kg dry weight					
		Length (cm)	Weight (g)	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
Pagellus erythrinus	5	15.5	58.4	4.1	0.023	6.9	0.47	0.62	16.5
Sphyraena sphyraena	5	21.5	62.5	10.5	0.018	7.8	0.19	0.65	16.5
Trigla hirundo	5	19.3	71.6	4.8	0.012	10.2	0.18	0.18	27.0
Siganus rivulatus	4	16.8	73.6	0.97	0.023	8.0	0.60	0.08	25.5

a) N = Number of fish in composite samples, composite concentrations are expressed as the mean of duplicate determination

Table 2. Concentrations of arsenic, cadmium, copper, lead, mercury, and zinc in muscle tissue of fish from Idku and Maryut lakes, September 1985

Species	N [a]	Average Size		Metal Concentrations mg/kg dry weight					
		Length (cm)	Weight (g)	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
				El Qalaa drain - Maryut Lake					
Tilapia nilotica	5	15.4	61.7	0.18	0.018	15.4	0.42	0.05	39.0
				Forn El Gieraia - Maryut Lake					
Tilapia zillii	4	14.8	49.4	0.18	0.021	8.1	0.30	0.06	40.5
				Idku Lake					
Tilapia nilotica	5	16.3	69.5	0.11	0.023	3.0	0.28	0.04	31.5

a) N = Number of fish in composite samples, composite concentrations are expressed as the mean of duplicate determination

Table 3. Concentrations of arsenic, cadmium, copper, lead, mercury, and zinc in liver samles of fish from Abu Qir Bay, September 1985. Arithmetic mean and range

Species	N[a]	Metal Concentrations mg/kg dry weight					
		Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
Pagellus erythrinus	16	7.1 (6.4-7.9)	0.035 (0.025-0.042)	12.7 (7.7-15.8)	0.73 (0.60-0.75)	0.23 (0.15-0.30)	78.0 (68.2-80.8)
Sphyraena sphyraena	16	5.2 (4.6-5.8)	0.024 (0.018-0.028)	31.8 (29.8-32.1)	0.51 (0.43-0.55)	0.14 (0.07-0.20)	71.3 (65.6-73.3)
Trigla hirundo	14	5.2 (4.7-5.5)	0.018 (0.010-0.020)	11.7 (10.6-13.1)	0.35 (0.28-0.39)	0.95 (0.80-1.03)	61.5 (57.7-62.3)
Siganus rivulatus	10	4.5 (3.8-4.6)	0.108 (0.098-0.115)	14.1 (13.8-14.6)	0.98 (0.85-1.30)	0.45 (0.39-0.50)	60.0 (50.8-64.5)

a) N = Number of individual fish livers analyzed

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