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Research Article

Levels of Heavy Metals (Cd, Pb, Cu, Cr and Ni) in Tissue of *Cyprinus carpio*, *Barbus capito* and *Chondrostoma regium* from the Seyhan River, Turkey

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Abstract: Concentrations of cadmium, lead, copper, chromium and nickel were determined in the gill, liver and muscle of *Cyprinus carpio, Barbus capito* and *Chondrostoma regium* caught at 5 stations on the Seyhan river system. Heavy metal concentrations in the tissues tended to vary significantly among stations, and one station thought to be contaminated by hospital effluents showed particularly high metal concentration. Liver and gill tissues showed higher metal concentrations than muscle tissue. The ranges of mean metal concentrations (μg/g d.w.) were as follows: the range of cadmium concentration was 1.26-6.10, 0.96-4.72 and 0.51-1.67, that of lead was 9.41-44.75, 5.22-37.15 and 2.94-13.73, that of copper was 5.43-58.63, 5.91-201.1 and 3.27-7.35, that of chromium was 1.72-6.10, 0.23-5.35 and 0.36-1.71 and that of nickel was 6.83-28.03, 3.42-27.05 and 1.62-13.35 in the gill, liver and muscle respectively. The concentrations of some metals in some tissues exceeded the acceptable levels for a food source for human consumption. The least contaminated part of the river system was found to be Seyhan Dam, which does not receive significant levels of effluents from industrial and domestic sources in Adana when compared to other stations. The results of this study indicated that the metals present in the river system were taken up by three fishes through food, water and sediment, as all the fish species, regardless of their biological needs, showed high metal concentrations.

Key Words: Metal, Accumulation, Fish, *Cyprinus carpio, Barbus capito, Chondrostoma regium.*

Seyhan Nehrinde yaşayan balıkların (*Cyprinus carpio, Barbus capito* ve *Chondrostoma regium)* Dokularında Ağır Metal (Cd, Pb, Cu, Cr ve Ni) Düzeyleri

Özet: Seyhan nehrinde 5 istasyondan yakalanan *Cyprinus carpio, Barbus capito* ve *Chondrostoma regium* un kas, karaciğer ve solungaç dokularında kadmiyum, kurşun, bakır, krom ve nikel düzeyleri belirlendi. Dokulardaki ağır metal düzeyleri istasyonlar arasında genellikle önemli oranlarda değişim göstermiş olup, özellikle hastahane akıntıları tarafından kontamine edildiği düşünülen bir istas- yon en yüksek düzeylerde ölçülmüştür. Karaciğer ve solungaç dokuları kas dokusundan daha yüksek düzeylerde metal biriktirmiştir. Balıkların dokularındaki ortalama metal derişimleri (μg/g k.a) aşağıdaki şekildedir: Solungaç, karaciğer ve kas dokularındaki kadmiyum düzeyleri sırasıyla 1.26-6.10, 0.96-4.72 ve 0.51-1.67 arasında, kurşun düzeyleri 9.41-44.75, 5.22-37.15 ve 2.94-13.73 arasında, bakır düzeyleri 5.43-58.63, 5.91-201.1 ve 3.27-7.35 arasında, krom düzeyleri 1.72-6.10, 0.23-5.35 ve 0.36-1.71 arasında değişim gösterirken, nikel için bu değişimler 6.83-28.03, 3.42-27.05 ve 1.62-13.35 arasında olmuştur. Bazı metallerin derişimleri bazı dokularda insan tüketimi için kabul edilebilir düzeyleri aşmıştır. Seyhan nehrinde en az kontamine olan kısım diğer istasyonlara nazaran Adana'nın evsel ve endüstriel atıklarını daha az alan Seyhan Barajı olarak bulunmuştur. Bu çalışmanın sonuçları nehirde bulunan metallerin üç balık tarafından besin, su ve sediment yoluyla alındığını vurgulamıştır. Çünkü biyolojik gereksinimleri ne olursa olsun bütün balıklar yüksek düzeylerde metal derişimleri göstermişlerdir.

Anahtar Sözcükler: Metal, Birikim, Balık, *Cyprinus carpio, Barbus capito, Chondrostoma regium*

Introduction

The contamination of freshwaters with a wide range of pollutants has become a matter of great concern over the last few decades, not only because of the threat to public water supplies, but also with of the damage caused to the aquatic life. The river systems may be excessively contaminated with heavy metals released from domestic, industrial, mining and agricultural effluents (1-4). Contamination of a river with heavy metals may have devastating effects on the ecological balance of the aquatic environment, and the diversity of aquatic organisms becomes limited with the extent of contamination (5).

Studies have shown that fish are able to accumulate and retain heavy metals from their environment and it has been shown that accumulation of metals in tissues of fish is dependent upon exposure concentration and duration, as well as other factors such as salinity, temperature, hardness and metabolism of the animals (6-10). Once heavy metals are accumulated by an aquatic organism they can be transferred through the upper classes of the food-chain. Carnivores at the top of the food-chain, including humans, obtain most of their heavy metal burden from the aquatic ecosystem by way of their food, especially where fish are present so there exists the potential for considerable biomagnification (3, 4, 11). Studies carried out on fish have shown that heavy metals may have toxic effects, altering physiological activities and biochemical parameters both in tissues and in blood (12-18).

Since the toxic effects of metals have been recognized heavy metal levels in the tissues of aquatic animals are occasionally monitored. Because the heavy metal concentration in tissues reflects past exposure via water and/or food, it can demonstrate the current situation of the animals before toxicity affects the ecological balance of populations in the aquatic environment.

The Seyhan River is an important water supply for the agricultural land of Çukurova and also a fishing place for commercial and amateur fishing. It runs from Central Anatolia to the Mediterranean Sea. Unfortunately, it has been contaminated by domestic, industrial and agricultural effluents coming from various towns including Adana, a city with a population of 1 million and a large agricultural region, Çukurova. Thus, this study was undertaken to investigate the current heavy metal contamination in the Seyhan river, by studying three fish species with different ecological needs. It was initially planned to study metal concentrations in the tissue of fishes in different seasons as well. However, the amount of water released to most of the study areas changes seasonally due to the dams built on the river to deliver water for field irrigation. Therefore, the seasonal study was cancelled because the metal concentration in the water could change artificially in different seasons.

Materials and Methods

Nets were used to catch adult *Cyprinus carpio* (21.1±1.9 cm and 138.4±23.3 g), *Barbus capito* (22.3±2.7 cm and 129.4±38.6 g) and *Chondrostoma regium* (17.4±1.7 cm and 59.5±7.8 g). Ten fish of each species from each stations were used for analysis. The sizes and weights of the animals did not vary significantly from station to station ($P>0.05$).

Fish sampling was done at 5 stations from the Seyhan river in 25-30 November 1996 when irrigation season was over, so water was running naturally. Stations shown on the map (Figure 1) were chosen in relation to the contamination gradient. Station 1 (Seyhan Dam) is a relatively clean area of the river system because it is north of industrial and agricultural areas of Adana, and is therefore relatively less affected from contaminated effluents. The other stations, however, receive many industrial and domestic effluents from Adana and surrounding areas. Station 2 is located at the site of a small dam built for field irrigation and receive effluents from domestic sources, hospitals and other sources. The other stations are from normal flowing parts of the river (water runs faster in those areas), but they also receive additional inputs from sewage waters.

In the same day of capture the Animals were brought to the laboratory as soon as they were caught and dissected with clean instruments. The tissues of ten fish of the same species from the same station were pooled to make 3 subsamples. Gill, liver and muscle tissue was put in petri dishes to dry at 120°C until reaching a constant weight. Dry gill (0.423±0.165 mg), liver (0.307±0.088 mg) and muscle (0.682±0.144 mg) tissue was put into digestion flasks and 4 ml percholic acid and 8 ml nitric acid (Merck) were added. The digestion flasks were then put on a hot plate set to 130°C (gradually increased) until all materials were dissolved. Digestes were diluted with distilled water appropriately in the range of the standards, which were prepared from the stock standard solution of the metals (Merck). Metal concentrations in the samples were measured using a Perkin Elmer AS 3100 atomic absorption spectrophotometer and given as µg metal/g dry weight.

Statistical Analysis of data was carried out with SPSS statistical package programs. Kruskall-Wallis one way ANOVA was used to compare data among stations.

Results

Mean concentrations and associated standard deviations of cadmium, lead, copper, chromium and nickel in the gill, liver and muscle of *Cyprinus carpio, Chondrostoma regium* and *Barbus capito* from 5 stations in the Seyhan river are shown in Tables 1a-e, along with the results of statistical comparisons of tissue metal concentrations. Figure 1 shows sampling stations in the Seyhan river.

Cadmium concentrations varied significantly ($P<0.05$) from station to station except in the muscle of *Cyprinus carpio* and in the liver of *Chondrostoma regium* (Table 1a). Station 2 generally showed the highest cadmium concentrations. Except in muscle tissue, mean cadmium concentrations were higher in *Chondrostoma regium* than in *Barbus capito* and *Cyprinus carpio.*

Lead concentrations varied significantly from station to station, except (P>0.05) in the gill of *Cyprinus carpio* and in the liver of *Chondrostoma regium* (Table 1b). The highest lead concenrtations were found in samples from Station 2, except in the muscles. Mean lead concentrations were higher in the liver and gill of *Chondrostoma regium* than in the same tissues of the other fish species.

Copper concentrations varied from station to station only in the gill and liver of *Chondrostoma regium* and in the liver of *Cyprinus carpio* and *Barbus capito* (table 1c). None of the stations consistently showed the highest copper concentrations. Mean copper concentrations were higher in the gill of *Chondrostoma regium* than in the same tissues of the other fish species.

Variations in chromium concentrations were significant only in the gill and liver of *Chondrostoma regium* and in the gill of *Barbus capito* (Table 1d). Station 2 showed the highest chromium concentrations in the tissues except in the muscle and gill of *Barbus capito.* Mean chromium concentrations were not particularly high among the fish species.

Nickel concentrations varied significantly from station to station in the gill tissue of all fish species (Table 1e). There were also significant differences in the liver of *Barbus capito* and in the muscle of *Chondrostoma regium.* Station 2 showed the highest nickel concentrations. Mean nickel concentrations were highest in the gill and liver tissue of *Chondrostoma regium* than in that of *Barbus capito* and *Cyprinus carpio.*

Discussion

Initially we expected that metal concentrations in the tissue of fish from Stations 4 and 5 would be highest as they are in the south of Adana, which receives more

Station		Gill	Liver	Muscle
CC	1	2.32±0.20	1.38±0.35	1.26±0.35
	2	2.15±0.41	2.63±1.04	0.85±0.13
	3	1.83±0.05	1.31±0.43	0.98±0.12
	4	2.17±0.21	0.96±0.14	0.89±0.20
	5	1.48±0.32	1.10±0.48	0.67±0.15
	Mean	1.99±0.38	1.51±0.80	0.93±0.27
	P Value	<0.05	<0.05	NS
CR	1	2.45±1.05	4.28±0.97	1.32±0.25
	2	6.10±1.94	4.72±1.39	1.23±0.37
	3	2.60±0.23	2.58±0.82	1.11±0.24
	4	2.03±0.36	4.25±1.99	0.56±0.08
	5	1.96±0.45	3.26±1.15	0.52±0.07
	Mean	3.03±1.83	3.82±1.38	0.95±0.41
	P. Value	<0.01	NS	<0.01
BC	1	2.16±0.28	2.59±0.75	0.94±0.34
	2	2.91±0.48	4.34±0.98	1.15±0.11
	3	1.35±0.75	1.87±0.80	1.67±0.40
	4	2.34±0.75	1.36±0.07	1.06±0.22
	5	1.26±0.26	1.24±0.15	0.51±0.07
	Mean	2.00±0.75	2.35±1.32	1.07±0.44
	P. Value	<0.01	<0.01	<0.01

Tables 1(a-e). Mean concentrations (μg metal/g d.w.) and associated standard deviations of cadmium (1a), lead (1b), copper (1c), chromium (1d) and nickel (1e) in the gill, liver and muscle tissue of *Cyprinus carpio* (CC), *Barbus capito* (BC) and *Chondostroma regium* (CR) caught at five stations in the Seyhan river. Results of statistical differences (P value) from station to station are indicated and the total mean concentrations of metals in each tissue for each fish species are also given. NS=not significant (P>0.05), NA=not available.

Table 1b.

Station		Gill	Liver	Muscle
CC	1	15.53±1.63	7.95±2.51	10.22±3.20
	2	17.14±3.73	15.93±3.63	7.13±0.90
	3	11.21±0.69	7.92±3.86	6.88±1.42
	4	14.25±1.83	6.77±0.64	6.65±1.89
	5	13.16±4.37	7.84±3.20	4.32±0.75
	Mean	14.23±3.17	9.45±4.39	7.04±1.93
	P Value	NS	<0.05	<0.05
CR	1	11.56±2.95	25.93±3.01	7.18±0.84
	2	44.75±3.54	37.15±12.1	8.90±2.69
	3	19.24±2.70	16.90±2.92	10.63±3.15
	4	11.95±2.11	25.34±8.79	3.25±0.31
	5	13.17±4.24	26.61±13.9	2.94±0.59
	Mean	20.10±13.3	26.37±10.3	6.58±3.54
	P value	<0.001	NS	<0.01
BC	1	16.96±1.59	16.81±2.81	8.19±2.57
	2	19.97±2.97	22.03±5.76	6.81±1.99
	3	9.41±2.59	11.02±3.18	13.73±2.00
	4	14.67±3.51	9.39±2.69	6.06±1.36
	5	9.52±1.38	5.22±1.54	3.09±0.66
	Mean	14.08±4.77	13.45±6.65	7.58±3.95
	P Value	<0.01	<0.05	<0.001

Table 1c.

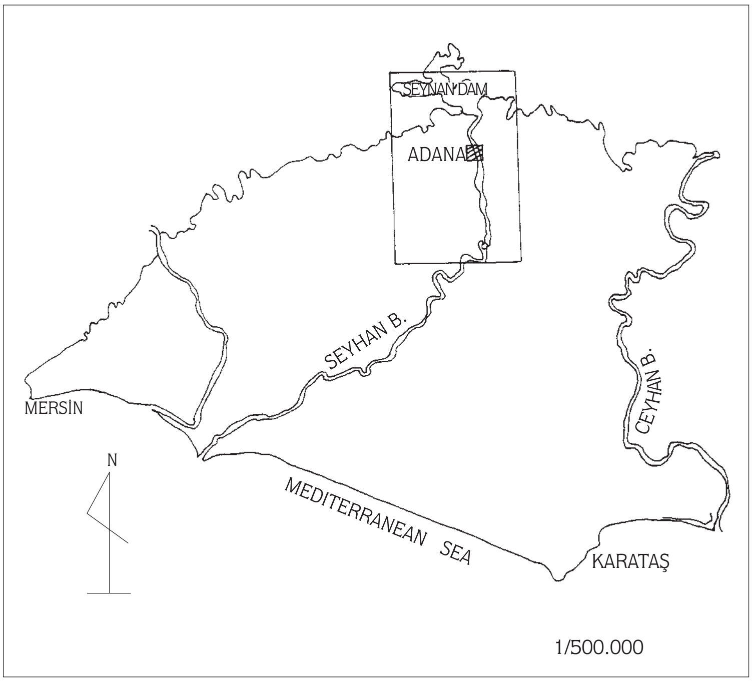
Station		Gill	Liver	Muscle
CC	1	7.54±0.30	52.71±31.0	6.57±5.25
	2	7.45±1.76	61.23±29.8	3.47±1.23
	3	6.22±1.01	13.92±8.34	6.20±0.16
	4	6.33±0.77	10.4±7.97	4.58±0.67
	5	7.51±1.45	15.43±7.54	4.79±0.48
	Mean	7.01±1.17	32.19±28.6	5.12±2.37
	P. Value	NS	<0.05	NS
CR	1	11.95±0.85	16.65±3.20	3.27±1.14
	2	58.63±4.02	73.01±33.5	4.67±0.80
	3	8.28±1.72	201.07±145	4.32±0.06
	4	10.53±0.45	56.43±3.93	4.23±0.47
	5	11.14±1.88	54.92±17.7	4.55±0.11
	Mean	20.09±20.0	80.60±86.6	4.21±0.76
	P Value	<0.001	<0.05	NS
BC	1	6.57±0.55	39.83±7.68	4.66±0.34
	2	8.55±1.53	102.08±31.3	4.77±0.48
	3	5.98±1.91	48.23±43.8	6.08±2.62
	4	5.43±1.00	5.91±1.79	7.35±5.50
	5	7.19±0.42	28.13±1.94	4.58±0.68
	Mean	6.75±1.56	46.02±40.1	5.49±2.58
	P Value	NS	<0.05	NS

Table 1d.

Station		Gill	Liver	Muscle
CC	1	1.81±0.31	0.23±0.35	0.56±0.92
	2	6.10±3.09	2.32±0.89	0.83±0.30
	3	2.39±0.63	1.30±0.41	0.78±0.40
	4	2.65±1.43	0.64±0.58	0.58±0.17
	5	5.75±1.56	0.54±0.38	0.36±0.08
	Mean	3.74±2.36	1.03±0.92	0.62±0.44
	P Value	<0.05	<0.01	NS
CR	1	2.15±3.14	2.66±3.11	1.18±0.47
	2	6.06±2.53	4.80±1.95	1.32±0.44
	3	2.14±0.99	2.73±1.96	0.54±0.19
	4	3.96±1.57	0.31±0.33	0.82±0.05
	5	NA	NA	0.82±0.14
	Mean	3.58±2.53	2.63±2.44	0.82±0.50
	P Value	NS	NS	<0.01
BC	1	2.30±0.06	2.22±0.57	0.91±0.14
	2	3.62±0.95	5.35±5.16	0.77±0.21
	3	1.72±0.17	1.44±0.34	1.71±1.20
	4	5.08±4.49	1.53±1.02	0.56±0.53
	5	5.03±0.16	0.95±0.70	0.43±0.06
	Mean	3.55±2.24	2.39±2.66	0.90±0.69
	P Value	<0.05	NS	NS

Table 1e.

Station		Gill	Liver	Muscle
CC	1	9.51±0.83	4.87±1.53	5.45±1.44
	2	15.93±6.43	11.15±3.43	6.11±0.72
	3	8.94±1.09	6.97±3.02	5.58±0.50
	4	9.80±0.59	5.71±1.48	6.21±3.08
	5	7.69±1.53	5.31±2.51	2.58±0.58
	Mean	10.37±3.91	6.87±3.25	5.19±1.93
	P Value	<0.05	NS	NS
CR	1	8.98±1.86	17.54±4.46	7.08±0.84
	2	28.03±4.55	27.05±8.21	8.43±3.38
	3	12.14±1.13	14.26±5.15	4.80±0.98
	4	11.55±1.60	19.74±7.30	2.19±0.24
	5	9.23±2.31	19.75±10.2	1.84±0.13
	Mean	13.99±7.70	19.65±7.60	4.87±3.07
	P Value	<0.001	NS	<0.01
BC	1	12.35±3.09	13.25±4.17	4.91±0.76
	2	15.55±3.04	19.24±4.39	13.35±14.3
	3	6.83±1.96	11.04±4.56	8.97±2.03
	4	12.75±2.46	6.90±1.63	7.27±3.56
	5	9.05±1.28	3.42±0.10	1.62±0.22
	Mean	11.21±3.84	11.28±6.22	7.21±6.94
	P Value	<0.05	<0.01	NS



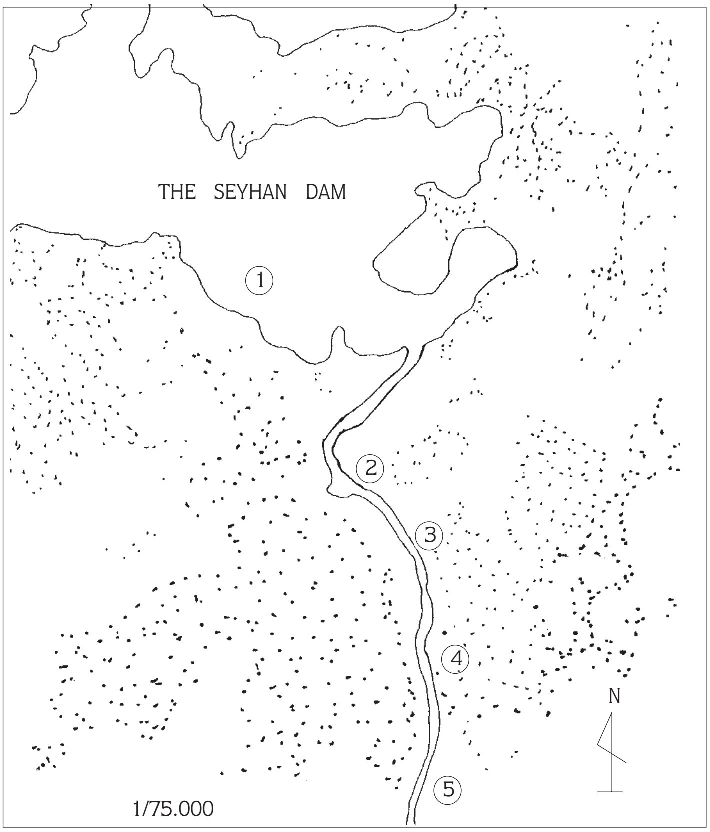


Figure 1. Maps of the Seyhan River system. Numbers show sampling stations of the fishes and dotted areas show the settlement regions of Adana.

untreated waste water from the river and surrounding environment. However, all fish species from Station 2 displayed the highest metal concentrations in their tissues. An investigation was carried out to determine the source of high metal input to this station and the results showed that several hospitals as well as domestic sources discharge untreated effluents in the vicinity of Station 2. The results of this study indicate that fish can accumulate heavy metals efficiently in areas where direct inputs occur; the literature states that metal uptake from water is much higher than uptake from sediment (3, 4, 25). The fact that fish from Stations 3-5 displayed lower metal concentrations than those from Stations 2 suggests that metals discharged in the vicinity of Station 2 are perhaps precipitated or adsorbed onto sediments due to interaction with some other compounds, so that fish at stations 3-5 are not exposed to the metals in water to the same degree as fish living at Station 2. From the results of this study, Station 1 (Seyhan dam) appears to be the cleanest part of the river system, probably because it does not receive many pollutants from industrial and domestic sources.

It is generally accepted that heavy metal uptake occurs mainly from water, food and sediment (bottom feeders and burrowing animals). However, the effiency 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 (6-9, 19, 20). Dallinger and Kautzky (21) indicated that the uptake of cadmium, copper and zinc from food could be the main route of metal uptake by rainbow trout *Salmo gairdneri,* although high levels of elimination through faeces occur. Kilgour (22) pointed out that the release of cadmium from sediment can increase the cadmium concentration in the water and indicated that bottom-feeding and burrowing animals showed relatively high body concentrations of cadmium, although uptake from water was a more important route for other animals. It seems that fish in the Seyhan River are exposed to metals in water, food and sediment because all fish species, regardless of their ecological needs, accumulated high levels of the metals studied here.

Whatever the source of metals, the results of the present study showed that concentrations of cadmium, lead, copper, chromium and nickel were very high at nearly all stations when compared to data obtained from uncontaminated waters (1, 23, 24). The levels of some metals were even higher than the acceptable values for human consumption designated by various health organisations (25). Especially when one considers that stations chosen here are from areas which are important for commercial and amateur fishers and also for leisure (Stations 1 and 2), these results should serve as a warning.

From the fish health point of view, the results of the present study may also be considered as an important warning signal. 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 (17, 18, 26-28). Target organs, such as the liver and gills, are metabolically active tissues and accumulate heavy metals in higher levels, as was observed in experimental (10, 17, 29, 30) and field studies (4, 26, 31, 32).

In the literature, heavy metal concentrations in the tissue of freshwater fish varies considerably among different studies, possibly due to differences in metal concentrations and chemical characteristics of water from which fish were sampled, eocological needs, metabolism and feeding patterns of fishes and also the season in which studies were carried out. Norris and Lake (31) found the highest metal concentrations in the liver, followed by the gill and muscle in fishes from South Esk River in Tasmania and indicated that no fish were caught at a heavily polluted station, possibly due to hindrance of aquatic life. The order of metal accumulation in the tissues of this study was also supported by the present results. Cumbie (11) also found considerable differences in mercury concentrations in the muscle of different fish from the Suwannee River in Georgia, indicating that metabolic activities of different fish species may be an important factor in mercury accumulation. Dallinger and Kautzky (21) also found similar distribution patterns of metals in *Salmo gairdneri .* Highest concentrations of Zn, Pb, Cd, Cr and Ni were observed in the gill of *Salmo gairdneri,* followed by the liver and muscle, while Cu concentrations was highest in the liver, followed by the gill and muscle. They also indicated that different concentrations of heavy metals in different fish species might be a result of different ecological needs, metabolism and feeding patterns. Lead concentrations in the muscle of the eel *Anguilla anguilla* and the roach *Rutilus rutilus* from various aquatic areas of the UK ranged up to 7.40 and 8.70 ppm, while cadmium levels ranged up to 1.88 and 1.07 ppm in the eel and roach, respectively (34). Camusso *et al.* (32) studied filed bioaccumulation of heavy metals in the tissues of rainbow trout *Salmo gairdneri* exposed to contaminated water. They found that two different experimental stations of the River Po showed different metal concentrations after 30 days, indicating stations contaminated heavily caused the fish to accumulate heavy metals in greater levels. They found metal accumulation in the tissues in the following order: Pb in the bone, spleen and kidney, Cr in the spleen, muscle and gills, Cu in the kidney, Zn in the gills. However, they did not study the liver, which is an important organ in metal accumulation, so these orders may be incomplete. Whole body cadmium and zinc concentration, were found to be very high in fish from industrially contaminated lakes in the USA, highest cadmium and zinc concentrations being 13.60 and 820 ppm d.w., respectively (33). Sharif *et al.* (24) studied metal concentrations in the edible parts of ten freshwater fish species from Bangladesh. The ranges of iron, nickel, copper and zinc concentrations were 31.8-296, 1.20-6.10, 23.31-48 and 33.01-286 ppm, respectively. The ranges of lead and cadmium levels were 0.29-10.05 and 0.04-0.13 ppm, respectively. The researchers indicated that these variations were most likely due to the various living and feeding habits of different species of fish. It is also possible that the geographical locations of catch, season, nature of diet, and the size of fish used for analyses could lead to different metal concentration in the same fish species. May and McKinney (23) indicated that heavy metal concentrations in the whole body of different freshwater fishes from 98 monitoring stations in the US ranged between 0.01-1.04 ppm for cadmium and 0.1-0.32 ppm for lead. It seems that metal concentrations in the tissue of fish from the Seyhan River are, in general, higher than those in the literature, indicating that metal contamination in the river is too high for the health of fish and the people who eat them.

The major findings of this study are that heavy metal concentrations in the gill, liver and muscle tissue of *Cyprinus carpio, Chondrostoma regium* and *Barbus capito* from the Seyhan river were very high and in general displayed significant variation from station to station. Certain heavy metal levels reached unacceptable levels for human consumption. Because high metal concentrations in tissue can have toxic effects on fish metabolism, it is important to consider the biological effects of contamination on fish health in the river.

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