

Original Research

# Toxic and Trace Element Levels in *Salmo trutta macrostigma* and *Oncorhynchus mykiss* Trout Raised in Different Environments

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## Abstract

The increase in human population along with economic and technological developments has led to significant degrees of deterioration in water quality globally. As a result, it is important to determine the toxic metal concentrations in organisms living in water, especially in commonly consumed fish species. With this aim, due to the shallow water in our region we chose the important trout production location of the Çatak River for sampling in our study, using natural *Salmo trutta macrostigma* and *Oncorhynchus mykiss* from the river and *Salmo trutta macrostigma* and *Oncorhynchus mykiss* bred in a trout production facility in Çatak District. These fish had element levels (Be, B, Al, Ti, Cr, Mn, Co, Ni, Cu, Zn, Mo, Cd, Ba, Pb, Na, Mg, Si, K, Ca, Fe, As, Se, and Sb) measured in heart, muscle, liver, kidney, gills, gonads, brain, and intestinal tissue using an ICP-OES device. The results of the study are grouped as toxic (Be, Cd, Pb, Al, Ba, Ti), trace (Fe, Zn, Cu, Mn, Co, Ni, Cr, B, Si, Mo) and macro (Ca, Mg, K, Na) elements for assessment. As a result, the nutrient values of the trout grown on the farm and in the natural environment were high.

**Keywords:** toxic elements, trace elements, macro elements *Oncorhynchus mykiss*, *Salmo trutta macrostigma*

## Introduction

Aquaculture has developed rapidly around the world. The rainbow trout (*Oncorhynchus mykiss*) has a place in freshwater aquaculture [1]. In this respect, rainbow trout has become a focus in terms of both economic and nutritional importance [2]. In addition to land-based food, aquaculture is important for its nutritional value. The World Health Organization has

stated that fish consumption should be 12 kg per year per person [3]. Today, fish are regarded as an important source of protein after investigating their components and their effect on our health [4]. Trace elements, depending on their concentration, may have beneficial or harmful effects on human health. These elements are important, as they act as antioxidants in the body, and they are the cofactors of several enzymes. They also act as the structural components of metalloenzymes and metalloproteins and are included as stabilizers in membranes [5-6].

Water resources are increasingly polluted due to rapid advances in technology and industry. Identification

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and quantification of pollution sources and protection of the quality of surface waters are crucial, since the adequate quality and quantity of water are essential for sustainable development [7]. Environmental pollution is a growing threat for the ecosystem and humans. The most dangerous environmental pollutants are heavy metals because they cannot be degraded and persist in the environment for a long time [8]. Heavy metals also have toxic effects on aquatic animals. Heavy metals form insoluble organometallic compounds in the gills of fish. These compounds are carried into the bloodstream and tissues of fish [9]. Fish are an important protein source in the biological cycle. Increased accumulation of heavy metals in fish negatively affect the health of organisms feeding on fish [10]. Heavy metals constitute a risk factor for certain diseases by impairing the stability of elements at high or low concentrations [11].

There are very few studies on trout cultivated and found naturally in Turkey. The valley of the two Çatak rivers in Van Province is important for trout production due to the cool waters. The surrounding area is forested and has a reputation for the Çatak River trout. For this reason, in this study samples were taken from the Çatak district in Van province. In the study, toxic, trace, and macro element levels in *Salmo trutta macrostigma* and *Oncorhynchus mykiss* bred on farms and living in their natural habitats were determined. These fish have great commercial significance and are consumed in large quantities by the public. The study aimed to determine the effect of heavy metals and trace elements contained in these fish on consumers' health. A comparison was also made between trace element and heavy metal levels in trout cultivated on farms and living in their natural environment.

## Materials and Methods

### Fish Sampling

In this study, 50 rainbow trout weighing 250-300 g aged 2-3 years were analysed. The fish



Fig. 1. Çatak township map of Van Province in Turkey.

were taken from the Çatak River in Çatak District of Van Province, and from a trout farm nearby (Fig. 1). Ten freshwater trout (*Salmo trutta macrostigma*) and 10 rainbow trout (*Oncorhynchus mykiss* Walbaum 1792) were caught from the Çatak River. Fifteen freshwater trout (*Salmo trutta macrostigma*) and 15 rainbow trout (*Oncorhynchus mykiss* Walbaum 1792) were obtained from the fish farm. After the determination of weight (g) and sex under laboratory conditions, they were stored in a freezer at -20°C until the analysis process of muscle, liver, gill, gonad, heart, kidney, intestinal, and brain tissues. Age determination was made based on the operculum sample taken from each fish.

### Sample Preparation

Approximately 1 g of the tissues from the frozen fishes was weighed. The tissues, prepared according to the Alam et al. [12] method, were placed in glass tubes. Three ml of a 65% solution of HNO<sub>3</sub> (Merck, Germany) and 36.5% of HCl (Merck, Germany) 1:1 solution was added to the tissues. The samples were left at room temperature for 1 hour. The tissues were kept in an incubator for 3 hours at 200°C for breakdown of the tissues.

1N 2 ml of solution prepared with 65% HNO<sub>3</sub> was added to the completely dry tubes, and the drying process was repeated in the 200°C incubator. This process should be repeated until there is no remnant left in the tubes. In the last stage, after the dried tubes were cooled, 2.5 ml of 1N HNO<sub>3</sub> was added and the volume was completed to 10 ml with deionized distilled water and prepared for analysis. Prepared tissues were analysed with ICP-OES (Thermoscientific ICAP 6000 Series) (0.005 ppm detectable limit) and the levels of Be, B, Al, Ti, Cr, Mn, Co, Ni, Cu, Zn, Mo, Cd, Ba, Pb, Na, Mg, Si, K, Ca, Fe, As, Se, and Sb elements were determined.

### Statistical Analysis

*Salmo trutta macrostigma* and *Oncorhynchus mykiss* trout grown in the farm are among themselves; the *Salmo trutta macrostigma* and *Oncorhynchus mykiss* trout that grow in the natural environment are also compared among themselves. After analysis of metal levels in samples from trout species, confidence intervals were calculated by determining the standard deviations of the results obtained. One-way analysis of variance (one-way ANOVA) and Tukey tests were applied to the data, and the differences between the data were determined ( $p < 0.05$ ).

## Result and Discussion

In recent years, the amount of fish consumed globally has rapidly increased due to high-quality protein, high amounts fatty acids, and mineral content

Table 1. Levels of toxic (Be, Cd, Pb, Ba, Al, Ti) and macro (Na, K, Ca, Mg) elements of *Salmo trutta macrostigma* grown in farm and natural environments (mg/kg ww; mean  $\pm$  S.E.).

	Toxic Elements							Macro Elements						
	Be	Cd	Pb	Ba	Al	Ti	Na	K	Ca	Mg				
<i>Farmed Salmo trutta macrostigma</i>														
Heart	0.0002 $\pm$ 0.00	0.003 $\pm$ 0.00	0.06 $\pm$ 0.02	0.77 $\pm$ 0.08	2.29 $\pm$ 0.87	1.96 $\pm$ 0.7	800.4 $\pm$ 153.2	1526.7 $\pm$ 692.4	66.4 $\pm$ 11.2	90.6 $\pm$ 22.3				
Gonad	ND	0.003 $\pm$ 0.00	0.04 $\pm$ 0.01	0.64 $\pm$ 0.12	1.85 $\pm$ 0.75	16.20 $\pm$ 5.0*	3473.3 $\pm$ 1278.4*	1573.3 $\pm$ 509.7*	80.3 $\pm$ 21.5	195.3 $\pm$ 51.6				
Liver	ND	0.006 $\pm$ 0.00	0.06 $\pm$ 0.02	0.90 $\pm$ 0.32	2.37 $\pm$ 0.90	3.85 $\pm$ 0.7	2393.3 $\pm$ 987.5*	1480.1 $\pm$ 499.7	88.6 $\pm$ 18.5	140.7 $\pm$ 47.8				
Intestine	0.0001 $\pm$ 0.00	0.009 $\pm$ 0.00	0.04 $\pm$ 0.01	1.01 $\pm$ 0.70	3.12 $\pm$ 0.78	4.30 $\pm$ 0.9	2113.3 $\pm$ 842.7*	1340.1 $\pm$ 443.5	710.6 $\pm$ 198.9	202.3 $\pm$ 63.0				
Gill	0.00006 $\pm$ 0.00	0.004 $\pm$ 0.00	0.05 $\pm$ 0.02	0.85 $\pm$ 0.24	4.08 $\pm$ 0.98	8.26 $\pm$ 3.4	2566.7 $\pm$ 963.4*	1986.7 $\pm$ 541.6	3733.3 $\pm$ 1069.3	346.7 $\pm$ 87.7*				
Kidney	0.0001 $\pm$ 0.00	0.014 $\pm$ 0.00	0.04 $\pm$ 0.01	0.90 $\pm$ 0.45	2.64 $\pm$ 0.82	4.60 $\pm$ 1.6	2533.3 $\pm$ 756.9*	1526.7 $\pm$ 498.1	480.9 $\pm$ 98.5*	174.7 $\pm$ 53.9				
Brain	ND	0.002 $\pm$ 0.00	0.04 $\pm$ 0.01	0.73 $\pm$ 0.28	1.66 $\pm$ 0.74	3.67 $\pm$ 0.9	746.6 $\pm$ 157.8	813.3 $\pm$ 256.3	58.7 $\pm$ 14.7	36.6 $\pm$ 12.5				
Muscle	ND	0.003 $\pm$ 0.00	0.05 $\pm$ 0.03	0.70 $\pm$ 0.32	2.28 $\pm$ 0.89	4.86 $\pm$ 1.0	1666.7 $\pm$ 427.1*	1560.8 $\pm$ 398.7	760.3 $\pm$ 134.4	320.5 $\pm$ 102.1				
<i>Natural Growth Salmo trutta macrostigma</i>														
Heart	ND	0.003 $\pm$ 0.00	0.05 $\pm$ 0.01	0.79 $\pm$ 0.12	2.22 $\pm$ 0.74	1.85 $\pm$ 0.5	1026.7 $\pm$ 403.7	1186.7 $\pm$ 397.1	73.3 $\pm$ 23.8	71.3 $\pm$ 28.9				
Gonad	0.000005 $\pm$ 0.00	0.006 $\pm$ 0.00	0.02 $\pm$ 0.00	0.86 $\pm$ 0.29*	5.68 $\pm$ 1.67*	14.20 $\pm$ 4.1	910.7 $\pm$ 211.5	1020.2 $\pm$ 300.8	153.5 $\pm$ 50.6	150.4 $\pm$ 71.4				
Liver	ND	0.020 $\pm$ 0.00*	0.04 $\pm$ 0.01	0.80 $\pm$ 0.45	2.66 $\pm$ 0.98	4.94 $\pm$ 0.9	1380.3 $\pm$ 498.9	1473.3 $\pm$ 641.2	106.7 $\pm$ 43.6	142.8 $\pm$ 86.5				
Intestine	0.0002 $\pm$ 0.00	0.032 $\pm$ 0.01*	0.07 $\pm$ 0.02*	1.02 $\pm$ 0.78	10.29 $\pm$ 3.76*	4.74 $\pm$ 1.2	1766.7 $\pm$ 798.0	1513.3 $\pm$ 568.7	873.3 $\pm$ 408.6	209.3 $\pm$ 58.9				
Gill	0.00004 $\pm$ 0.00*	0.006 $\pm$ 0.00	0.06 $\pm$ 0.01	1.05 $\pm$ 0.65*	16.61 $\pm$ 2.03*	10.40 $\pm$ 4.8*	1760.7 $\pm$ 530.7	1373.3 $\pm$ 309.5	3733.3 $\pm$ 1501.9	296.6 $\pm$ 81.3				
Kidney	0.00008 $\pm$ 0.00*	0.049 $\pm$ 0.02*	0.07 $\pm$ 0.03*	0.98 $\pm$ 0.29	6.28 $\pm$ 3.65*	6.62 $\pm$ 1.4*	1486.7 $\pm$ 309.4	1626.7 $\pm$ 609.5	230.6 $\pm$ 78.1	188.2 $\pm$ 73.5				
Brain	ND	0.005 $\pm$ 0.00	0.06 $\pm$ 0.01	0.89 $\pm$ 0.38	2.05 $\pm$ 0.90	1.82 $\pm$ 0.7	873.3 $\pm$ 200.7	620.4 $\pm$ 287.9	45.3 $\pm$ 11.2	29.3 $\pm$ 10.9				
Muscle	0.000003 $\pm$ 0.00	0.007 $\pm$ 0.00	0.11 $\pm$ 0.03*	1.17 $\pm$ 0.78*	5.20 $\pm$ 1.53*	9.65 $\pm$ 4.5*	806.6 $\pm$ 198.9	2073.3 $\pm$ 897.1*	1586.7 $\pm$ 641.1*	373.3 $\pm$ 91.6*				

\* $p$ <0.05, ND: not detectable

Table 2. Levels of trace elements (Fe, Cu, Zn, Mn, Ni, Co, Mo, B, Cr, Si) of *Salmo trutta macrostigma* grown in farm and natural environments (mg/kg ww; mean  $\pm$  S.E.).

Trace Elements										
	Fe	Cu	Zn	Mn	Ni	Co	Mo	B	Cr	Si
<i>Farmed Salmo trutta macrostigma</i>										
Heart	65.33 $\pm$ 11.36	4.96 $\pm$ 1.04	5.31 $\pm$ 2.33	0.85 $\pm$ 0.23	3.38 $\pm$ 1.66	0.11 $\pm$ 0.03	0.74 $\pm$ 0.23	5.87 $\pm$ 1.66	6.64 $\pm$ 3.33	76.66 $\pm$ 23.98
Gonad	44.00 $\pm$ 9.64	1.20 $\pm$ 0.78	5.23 $\pm$ 2.12	0.64 $\pm$ 0.33	2.73 $\pm$ 0.96	0.08 $\pm$ 0.02	0.61 $\pm$ 0.24	5.43 $\pm$ 1.54	5.99 $\pm$ 2.98	93.33 $\pm$ 37.74
Liver	120.00 $\pm$ 59.83	77.04 $\pm$ 24.21*	9.62 $\pm$ 3.33	1.02 $\pm$ 0.50	3.33 $\pm$ 1.12	0.10 $\pm$ 0.02	0.70 $\pm$ 0.27	6.22 $\pm$ 2.33	6.09 $\pm$ 2.66	96.00 $\pm$ 39.43
Intestine	82.67 $\pm$ 29.42	2.74 $\pm$ 0.98	141.83 $\pm$ 48.67*	1.74 $\pm$ 0.76	3.54 $\pm$ 1.26	0.11 $\pm$ 0.08	0.81 $\pm$ 0.37	6.49 $\pm$ 2.67	7.71 $\pm$ 3.98	107.33 $\pm$ 41.54
Gill	98.67 $\pm$ 23.68	2.73 $\pm$ 1.21	43.06 $\pm$ 12.21*	1.53 $\pm$ 0.59	2.93 $\pm$ 1.11	0.10 $\pm$ 0.01	0.66 $\pm$ 0.18	5.01 $\pm$ 2.10	6.80 $\pm$ 3.11	95.33 $\pm$ 40.07
Kidney	120.67 $\pm$ 49.21	2.08 $\pm$ 0.87	10.70 $\pm$ 5.63	1.34 $\pm$ 0.45	2.85 $\pm$ 0.98	0.12 $\pm$ 0.04	0.75 $\pm$ 0.28	6.02 $\pm$ 2.89	6.47 $\pm$ 2.95	97.33 $\pm$ 39.65
Brain	36.00 $\pm$ 11.31	2.38 $\pm$ 0.98	1.32 $\pm$ 0.67	0.68 $\pm$ 0.24	2.93 $\pm$ 1.24	0.08 $\pm$ 0.02	0.62 $\pm$ 0.20	5.85 $\pm$ 2.97	6.04 $\pm$ 3.10	66.66 $\pm$ 24.07
Muscle	48.67 $\pm$ 15.73	1.41 $\pm$ 0.76	5.01 $\pm$ 2.26	0.97 $\pm$ 0.45	2.99 $\pm$ 1.45	0.09 $\pm$ 0.03	0.65 $\pm$ 0.24	6.02 $\pm$ 3.05	6.61 $\pm$ 4.00	106.67 $\pm$ 38.76
<i>Natural Growth Salmo trutta macrostigma</i>										
Heart	72.67 $\pm$ 17.49	1.22 $\pm$ 0.46	5.80 $\pm$ 1.40	1.08 $\pm$ 0.66	4.83 $\pm$ 1.45	0.17 $\pm$ 0.06	0.95 $\pm$ 0.45*	5.99 $\pm$ 2.51	9.44 $\pm$ 3.99*	73.33 $\pm$ 28.17
Gonad	59.00 $\pm$ 9.54	0.38 $\pm$ 0.19	11.05 $\pm$ 4.50	1.27 $\pm$ 0.56*	4.20 $\pm$ 2.04*	0.18 $\pm$ 0.03	0.82 $\pm$ 0.38*	6.99 $\pm$ 2.98	8.90 $\pm$ 3.78*	106.00 $\pm$ 46.53
Liver	161.33 $\pm$ 65.12*	55.56 $\pm$ 19.8	14.36 $\pm$ 6.13	1.53 $\pm$ 0.75*	4.66 $\pm$ 2.11	0.22 $\pm$ 0.10	1.00 $\pm$ 0.43*	6.14 $\pm$ 3.56	9.33 $\pm$ 4.08*	90.66 $\pm$ 42.55
Intestine	102.00 $\pm$ 43.67*	2.26 $\pm$ 1.05	69.60 $\pm$ 22.55	3.24 $\pm$ 1.98*	4.91 $\pm$ 2.68	0.30 $\pm$ 0.12*	0.96 $\pm$ 0.16	6.41 $\pm$ 4.48	9.52 $\pm$ 3.08	98.00 $\pm$ 39.07
Gill	88.67 $\pm$ 22.43	0.88 $\pm$ 0.34	15.43 $\pm$ 6.60	2.03 $\pm$ 1.11*	4.78 $\pm$ 1.98	0.22 $\pm$ 0.09	1.00 $\pm$ 0.26*	5.07 $\pm$ 2.09	9.15 $\pm$ 4.67	84.00 $\pm$ 33.22
Kidney	184.67 $\pm$ 77.42*	1.23 $\pm$ 0.56	12.56 $\pm$ 5.76	1.37 $\pm$ 0.78	5.20 $\pm$ 2.05*	0.39 $\pm$ 0.19*	1.11 $\pm$ 0.63*	6.78 $\pm$ 3.51	9.99 $\pm$ 4.33*	99.33 $\pm$ 42.50
Brain	44.67 $\pm$ 10.50	0.85 $\pm$ 0.23	2.55 $\pm$ 1.09	1.01 $\pm$ 0.66	4.84 $\pm$ 2.04	0.14 $\pm$ 0.06	0.96 $\pm$ 0.66*	6.17 $\pm$ 4.04	9.11 $\pm$ 4.56*	65.33 $\pm$ 27.66
Muscle	62.66 $\pm$ 17.87	0.78 $\pm$ 0.12	7.54 $\pm$ 3.11	1.66 $\pm$ 0.43*	6.35 $\pm$ 3.22*	0.18 $\pm$ 0.06	1.16 $\pm$ 0.63*	6.74 $\pm$ 4.69	11.44 $\pm$ 5.49*	112.00 $\pm$ 51.10

\* $p < 0.05$

[13-14]. The increase in human population and economic and technological developments has led to significant degrees of deterioration in water quality globally [15-16]. In this situation, more and more polluting material is emptied into water resources and rivers, causing water pollution and eutrophication. As a result, it is important to determine the toxic metal concentrations in organisms living in water – especially in commonly consumed fish species [17-18].

In *Salmon trutta macrostigma* fish cultivated on a farm we found Cr > Mo in the heart tissue; Na > K > Ti > Cr > Ni > Mn > Ba > Mo in the gonad tissues; Na > Fe > Cu > Cr > Mn > Mo > Cd elements in the liver tissue; Na > Fe > Zn > Al > Mn > Pb > Co > Cd in the intestine; Zn > Al > Ti > Mn > Ba > Mo > Be in the gill tissue; Na > Ca > Fe > Cr > Ti > Al > Ni > Mo > Co > Cd > Be in kidney tissue; Cr > Mo in brain tissue; and K > Na > Ca, > Mg > Cr > Ti > Ni > Al > Mo > Ba > Mn > Pb > Cd in muscle tissues were found to be significant compared to those found in the natural environment (Tables 1-2;  $p < 0.05$ ).

A study of tissues from *C. carassius* and *C. gigas* fish found in Meilian Bay of Lake Taihu in China identified generally high doses of heavy metals (Pb, Cd, Cr, and Cu). The study stated that this was due to disruption of the ecosystem, industrialization, and multiple aspects of human activity [18]. Again, in the South China Sea, element levels (Cd, Pb, Cr, Ni, Cu, and Zn) were determined in naturally cultivated fish species with trade value (*Thunnus obesus*, *Decapterus lajang*, *Cubiceps squamiceps*, and *Priacanthus macracanthus*). The values found were reported not to form a danger in terms of health [19]. Varol et al. [20] researched the Co, Cr, Cu, Fe, Mn, Ni, As, Pb, Cd, and Zn element levels and accumulation in the body with continuous consumption in a trace element study of rainbow trout found in a fish farm on the Euphrates River. They stated that heavy metal levels exceeded levels permitted by international health organisations. In our study, some of the values found appear to be in parallel with this study.

In *Oncorhynchus mykiss* fish cultivated on a farm, K > Cr > Ni > Co > Pb > Cd in the heart; K > Na > Mg > Ni > Ti in the gonad; Na > Cu > Ti > Mo > Co > Pb > Cd in liver tissue; Zn > Cu > Al > Mo > Co > Pb > Cd in the intestinal tissue; Ca > K > Na > Mg > Fe > Ti > Al > Cr > Zn > Mn > Ni > Ba > Co > Pb in the gill tissue; Na > Fe > Cr > Ti > Ni > Co > Pb > Cd in kidney tissue; Mg > Ca > Si > Fe > Ti > Zn > Al > Co > Cd in the muscle tissues were found to be significant compared to those found in the natural environment (Table 3) (Table 4;  $p < 0.05$ ).

A study of *M. galloprovincialis* and *T. Decussatus* species found in Homa Lagoon researched the Hg, Cd, Pb, Cr, Zn, and Cu element concentrations. The study stated that heavy metal levels posed a potential risk due to increasing environmental pollution [21]. A study researching the variation of some metal levels in *Alburnus tarichi* fish species analyzed the presence of

Be, Bi, Pb, Cd, Fe, Cu, Zn, Se, Ni, and Mn elements. They reported that this situation was a result of environmental pollution [22]. Qin et al. [23] determined the trace element levels (Li, V, Cr, Mn, Fe, Ni, Cu, Mo, Zn, Se, Sr, Al, Ti, As, Cd, Sb, Ba, Hg, Pb, and U, Co, Be, Ga, Ag, Sn, Te, Tm, and Tl) in carp obtained from three separate fish farms in China. In our study, the toxic element levels appear to be higher than in this study. However, the Pb and Cd toxic element levels in fish tissue were identified to be below the maximum limits determined by the Turkish Food Codex [24] and European Communities Commission Regulation [25]. In both fish species, Be element was determined in some tissues (Tables 1-3). However, the level of beryllium, which has toxic effects in fish, has not been reported in the literature. Gill tissue from the fish found in the natural environment appeared to have values higher than the previously mentioned study, especially for Al and Ti levels. This situation may be due to water pollution and agricultural pesticides used in the area surrounding the river. The levels of the toxic element Ba were in parallel with other literature results.

A study by Bhourri et al. [26] in Tunisia determined the K, Na, Ca, Mg, Fe, Zn, Cu, and Mn element concentrations in muscle and liver tissue of natural sea bass and sea bass cultivated in cages at sea. The cage-raised fish had higher Mn and Zn element concentrations compared to the fish found in the natural environment. They stated that the difference in these values may be due to feeding. In our study, element levels in fish species found in both environments were in parallel with these study results.

Avigliano et al. [27] researched the heavy metal and trace element levels in muscle tissue of silverside fish found in different regions in Argentina. The study identified As, Ag, B, Ba, Bi, Ca, Cd, Co, Cr, Fe, Ga, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Rb, Sb, Se, Sn, Sr, Te, Ti, U, V, and Zn element levels. They found toxic As, Hg, and Pb levels high enough to threaten health. In our study, the *Salmo trutta macrostigma* found in the natural environment had higher Cd, Pb, Ba, Al, Fe, Mn, Ni, Co, and Cr elements, while the farm-cultivated fish had higher Na, Cu, and Zn elements in some tissues, with significant differences (Tables 1-2). For the *Oncorhynchus mykiss* species, fish in the natural environment had higher levels of Cd, Pb, Ba, Al, Fe, Mn, Ni, and Cr, while farm fish had higher Mo with significant differences (Tables 3-4). These differences are considered to be due to fish on farms being fed in a springwater environment, while fish in the natural environment feed on aquatic organisms in the river affected by all sorts of external factors. A study was carried out to evaluate the trace element bioaccumulation of the Krka River to assess the present pollution status and the analysis of various biomarkers in the gill and cytoplasm (*Salmo trutta* L.) of brown trout. Concentrations of trace elements in the gill and cytosol were determined by ICP-MS. Seven (Co, Cu, Fe, Mn, Se, V, and Zn) and six (As, Cd, Cs, Rb, Sr,

Table 3. Levels of toxic (Be, Cd, Pb, Ba, Al, Ti) and macro (Na, K, Ca, Mg) elements in *Oncorhynchus mykiss* grown in farm and natural environments (mg/kg ww) (mean  $\pm$  S.E.).

	Toxic Elements						Macro Elements					
	Be	Cd	Pb	Ba	Al	Ti	Na	K	Ca	Mg		
<i>Farmed Oncorhynchus mykiss</i>												
Heart	ND	0.0024 $\pm$ 0.00	0.03 $\pm$ 0.01	0.64 $\pm$ 0.1	1.54 $\pm$ 0.5	1.69 $\pm$ 0.89	646.6 $\pm$ 243.1	1226.7 $\pm$ 491.3*	46.97 $\pm$ 12.9	64.23 $\pm$ 17.9		
Gonad	ND	0.0029 $\pm$ 0.00	0.03 $\pm$ 0.01	1.03 $\pm$ 0.4	2.41 $\pm$ 0.7	12.12 $\pm$ 5.5*	986.6 $\pm$ 345.1*	1080.7 $\pm$ 200.7*	96.22 $\pm$ 29.9	144.43 $\pm$ 29.8*		
Liver	ND	0.0042 $\pm$ 0.00	0.03 $\pm$ 0.02	0.73 $\pm$ 0.2	1.93 $\pm$ 0.7	4.50 $\pm$ 2.04	232.7 $\pm$ 989.5*	1933.3 $\pm$ 654.9	146.66 $\pm$ 47.2	217.33 $\pm$ 98.6		
Intestine	ND	0.0032 $\pm$ 0.00	0.03 $\pm$ 0.01	0.80 $\pm$ 0.5	1.96 $\pm$ 0.3	6.10 $\pm$ 3.56	1320.4 $\pm$ 543.8	1413.3 $\pm$ 397.6	96.22 $\pm$ 22.9	141.78 $\pm$ 39.9		
Gill	ND	0.0042 $\pm$ 0.00	0.03 $\pm$ 0.01	1.35 $\pm$ 0.5	2.65 $\pm$ 0.9	10.19 $\pm$ 4.97	1720.3 $\pm$ 459.7	1473.3 $\pm$ 379.7	3666.7 $\pm$ 1543.0	320.6 $\pm$ 71.8		
Kidney	ND	0.0092 $\pm$ 0.00	0.04 $\pm$ 0.02	0.91 $\pm$ 0.9	3.02 $\pm$ 1.5	4.76 $\pm$ 2.04	2466.7 $\pm$ 777.5*	1520.6 $\pm$ 504.6	286.66 $\pm$ 67.6	159.33 $\pm$ 49.1		
Brain	ND	0.0023 $\pm$ 0.00	0.04 $\pm$ 0.01	0.70 $\pm$ 0.3	1.70 $\pm$ 0.6	1.71 $\pm$ 0.87	820.2 $\pm$ 151.6	853.33 $\pm$ 154.6	76.67 $\pm$ 29.3	36.67 $\pm$ 7.7		
Muscle	ND	0.0034 $\pm$ 0.00	0.04 $\pm$ 0.02	0.98 $\pm$ 0.6	3.55 $\pm$ 1.2	4.81 $\pm$ 1.92	666.7 $\pm$ 98.6	1606.7 $\pm$ 698.1	953.33 $\pm$ 378.9*	1320.7 $\pm$ 287.5*		
<i>Natural Growth Oncorhynchus mykiss</i>												
Heart	ND	0.005 $\pm$ 0.00*	0.09 $\pm$ 0.3*	0.83 $\pm$ 0.4	3.70 $\pm$ 2.1	1.77 $\pm$ 0.3	473.3 $\pm$ 78.5	780.4 $\pm$ 176.2	42.43 $\pm$ 9.8	44.33 $\pm$ 17.6		
Gonad	ND	0.0047 $\pm$ 0.00	0.05 $\pm$ 0.01	0.89 $\pm$ 0.7	3.54 $\pm$ 1.7	2.43 $\pm$ 0.8	226.1 $\pm$ 61.3	573.3 $\pm$ 157.8	72.66 $\pm$ 37.7	29.34 $\pm$ 8.8		
Liver	ND	0.009 $\pm$ 0.00*	0.06 $\pm$ 0.03*	1.15 $\pm$ 0.9	4.20 $\pm$ 1.5	8.47 $\pm$ 2.7*	1380.3 $\pm$ 434.9	1766.7 $\pm$ 708.9	193.333 $\pm$ 65.7	220.3 $\pm$ 78.5		
Intestine	0.00002.7 $\pm$ 0.00	0.024 $\pm$ 0.00*	0.09 $\pm$ 0.04*	1.28 $\pm$ 0.8	9.58 $\pm$ 5.5*	7.760 $\pm$ 2.7	1486.7 $\pm$ 435.9	1346.6 $\pm$ 459.2	340.63 $\pm$ 151.5	171.33 $\pm$ 64.3		
Gill	0.00023 $\pm$ 0.00	0.006 $\pm$ 0.00	0.07 $\pm$ 0.05*	1.92 $\pm$ 0.6*	20.83 $\pm$ 8.6*	27.47 $\pm$ 933*	2666.6 $\pm$ 678.1*	3000.0 $\pm$ 998.7*	10000.0 $\pm$ 3000.0*	573.3 $\pm$ 151.9*		
Kidney	ND	0.022 $\pm$ 0.00*	0.09 $\pm$ 0.03*	0.83 $\pm$ 0.4	3.63 $\pm$ 1.7	8.02 $\pm$ 3.5*	1500.2 $\pm$ 355.7	1813.3 $\pm$ 764.1	393.33 $\pm$ 69.5	233.3 $\pm$ 54.1		
Brain	ND	0.0036 $\pm$ 0.00	0.05 $\pm$ 0.01	0.79 $\pm$ 0.3	1.99 $\pm$ 0.7	1.53 $\pm$ 0.3	480.02 $\pm$ 151.2	440.33 $\pm$ 101.2	24.66 $\pm$ 6.3	16.26 $\pm$ 6.9		
Muscle	ND	0.006 $\pm$ 0.00*	0.04 $\pm$ 0.01	0.93 $\pm$ 0.3	6.05 $\pm$ 4.7*	8.30 $\pm$ 2.8*	866.67 $\pm$ 303.7	1606.7 $\pm$ 709.6	713.33 $\pm$ 265.7	313.3 $\pm$ 101.3		

\* $p < 0.05$ , ND: not detectable

Table 4. Levels of trace elements (Fe, Cu, Zn, Mn, Ni, Co, Mo, B, Cr, Si) of *Oncorhynchus mykiss* grown in farm and natural environments (mg/kg ww) (mean ±S.E.).

Trace Elements										
	Fe	Cu	Zn	Mn	Ni	Co	Mo	B	Cr	Si
Farmed <i>Oncorhynchus mykiss</i>										
Heart	82.72±33.03	0.94±0.36	4.99±2.66	1.03±0.45	3.85±1.02	0.12±0.00	0.81±0.24	5.98±1.67	8.61±3.66	71.33±30.6
Gonad	46.66±17.86	0.12±0.03	5.17±3.55	1.08±0.33	3.91±1.07	0.11±0.03	0.79±0.33	7.22±2.33	9.93±3.96	101.3±45.8
Liver	162.30±67.9	29.08±16.7	11.56±6.01	1.76±0.45	3.73±0.94	0.13±0.04	3.55±1.63*	6.34±2.17	8.79±2.33	114.6±47.3
Intestine	96.88±39.02	10.05±4.7*	7.24±3.99	1.29±0.94	3.83±1.11	0.12±0.02	1.72±0.55*	6.51±2.26	9.11±4.22	95.77±45.88
Gill	82.93±28.67	0.50±0.10	91.81±37.7*	3.38±1.33	3.12±0.98	0.11±0.02	0.68±0.20	5.23±2.10	7.48±3.50	88.66±39.68
Kidney	119.3±55.6	0.96±0.39	12.67±5.01	1.46±0.44	2.57±0.87	0.22±0.03	0.62±0.36	6.53±3.09	5.93±2.66	98.32±41.55
Brain	39.33±9.64	0.43±0.20	1.42±0.76	0.80±0.33	3.11±1.00	0.10±0.02	0.63±0.23	5.86±2.11	6.74±3.01	68.49±27.87
Muscle	59.33±21.37	0.89±0.45	35.98±7.56*	2.10±0.76	3.99±1.70	0.21±0.06*	0.80±0.26	6.72±3.10	8.62±4.78	423.3±143.6*
Natural Growth <i>Oncorhynchus mykiss</i>										
Heart	76.09±22.50	1.61±0.33	3.75±1.00	1.37±0.49	7.57±2.89*	0.19±0.04*	1.18±0.27	6.27±2.66	11.73±5.23*	64.66±22.04
Gonad	49.33±17.32	0.97±0.35	7.22±2.12	1.17±0.50	17.93±4.50*	0.15±0.50	0.87±0.13	9.20±5.63	9.29±3.96	106.6±43.9
Liver	179.3±93.0	82.28±34.7*	23.53±7.89	2.18±0.60	4.96±1.54	0.27±0.00*	1.12±0.33	7.37±3.47	9.92±3.33	100.6±33.5
Intestine	98.08±39.66	1.88±0.70	111.0±78.5*	2.37±0.63	5.74±2.09	0.23±0.01*	1.06±0.29	8.43±3.99	10.50±4.99	110.8±38.5
Gill	172.7±78.9*	1.15±0.50	43.4±22.51	5.96±2.66*	5.31±2.98*	0.28±0.02*	1.13±0.26	5.94±2.33	10.66±4.07*	114.6±47.0
Kidney	192.6±98.7*	1.26±0.45	13.65±7.41	1.53±0.37	5.29±2.77*	0.34±0.10*	1.09±0.59	6.96±4.64	9.87±3.66*	106.6±55.7
Brain	40.66±11.2	2.69±0.79	1.43±0.64	1.01±0.26	4.78±2.15	0.13±0.01	0.92±0.47	6.55±3.98	9.35±3.78*	62.66±21.7
Muscle	282.0±106.3*	0.95±0.36	7.18±2.61	1.43±0.34	4.78±1.99	0.15±0.02	0.91±0.33	7.33±5.09	9.39±4.56	113.3±43.1

\*p<0.05

and Tl) elements were determined in the analysis [28]. It is seen that the results of our work are in parallel with this study.

### Conclusions

In conclusion, the Çatak District and Çatak River in Van Province were chosen for sampling due to their importance for commercial trout production. Natural *Salmo trutta macrostigma* and *Oncorhynchus mykiss* in the Çatak River and farm-cultivated *Salmo trutta macrostigma* and *Oncorhynchus mykiss* had toxic, trace, and macro element levels analysed in heart, muscle, liver, kidney, gill, gonad, brain, and intestinal tissues. In line with the obtained results, both fish species in the natural environment and cultivated on farms had high nutritional quality in terms of trace element and macro element levels. The dietary patterns of fish and the different water sources they live in may lead to the presence of different elemental values between the two groups. Furthermore, differences observed in element concentrations between the two fish groups are considered to vary linked to environmental conditions, mobility of fish, nutritional differences, and capacity for element accumulation. Additionally, the lack of identification of the Se element, with great importance for metabolism, and the toxic As and Sn elements is considered to be due to interaction between the elements during ICP-OES device measurements. As a result, it can be said that both of the trout grown in the farm and in the natural environment have high nutritional value.

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### Conflict of Interest

The authors declare no conflict of interest.

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