

# A Short-Term Study on Heavy Metal Concentrations in Gill, Kidney, Liver, Muscle and Skin Tissues of *Silurus glanis* L., 1758 from Çamlığöze Dam Lake, Sivas, Turkey

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**Abstract:** The concentrations of heavy metals (Ag, Cd, Cu, Fe, Pb) were analyzed in gill, kidney, liver, muscle and skin tissues of *Silurus glanis* L., 1758 from Çamlığöze Dam Lake located at Central Anatolian region of Turkey. The heavy metal analysis of samples was carried out by using a flame atomic absorption spectrophotometer. Ag, Cd and Cu were found in all of the examined tissues. Fe and Pb were not determined in all tissues studied. The mean concentrations of heavy metals in all of the examined tissues of *S. glanis* were as follows; Ag:  $0.038\pm 0.014$ – $0.157\pm 0.163$ , Cd:  $0.016\pm 0.001$ – $0.020\pm 0.001$  and Cu:  $0.045\pm 0.001$ – $0.346\pm 0.434$  µg/g. The obtained results were compared in terms of national limit values, international consumed and standard values. The concentrations of the tested heavy metals were within the acceptable standards.

**Keywords:** Bioaccumulation, Heavy Metals, *Silurus glanis*, Çamlığöze Dam Lake

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## 1. Introduction

Contamination of aquatic ecosystem is unquestionably a global environmental problem. With the increasing anthropogenic activities, toxic residues are continuously mobilized from different channels to the water environment. Heavy metal pollution is a great concern because of their long persistence, bioaccumulation and biomagnifications in the food chain [1, 2]. The European catfish, *S. glanis*, is native to eastern Europe and western Asia and is among the largest freshwater fish in the world. Despite its increasing economic importance and its frequent introductions, the ecology and life history of this species is poorly known due to the difficulty of sampling such a large species in large rivers and standing waters. The European catfish has an economic importance in commercial and recreational fisheries as well as in aquaculture. *S. glanis* is an economically valuable fish due to its very tasty flesh and lives in all freshwaters of Turkey except for Southeast Anatolia and the southern part of Eastern Anatolia [3, 4]. Predator fish like European catfish are at the top of food chain in the ecosystem, and can reflect the ambient metal concentrations [5]. The aim of this study was carried

out to investigate bioaccumulation of heavy metals (Ag, Cd, Cu, Fe, Pb) in gill, kidney, liver, muscle and skin tissues of *S. glanis* from Çamlığöze Dam Lake located at Central Anatolian region of Turkey.

## 2. Materials and Methods

### 2.1. Description of Study Area

This study was conducted in a manmade dam lake of Çamlığöze in Sivas, Turkey. Çamlığöze Dam Lake is located at Central Anatolian region of Turkey (Figure 1), longitude 40° 13' 45" N and latitude 38° 04' 36" E. The Çamlığöze Dam was constructed between 1987 and 1998 on the Kelkit Stream, a tributary of Yeşilirmak River. Çamlığöze Dam is a 37 m high rockfill a power plant. The water of Çamlığöze Dam Lake is mainly used for produce electrical energy, aquaculture, commercial fishing, irrigation, and recreation. The surface area and maximum depth of the Çamlığöze Dam Lake are 5 km<sup>2</sup> and 30 m respectively. Average capacity of Çamlığöze

Dam Hydroelectric Station is 102 GWh/year [6].

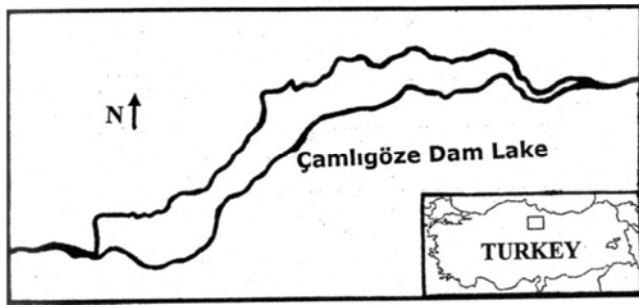


Figure 1. Çamlığöze Dam Lake.

## 2.2. Sampling and Sample Preparation

*S. glanis* specimens used in this study were caught with nets of 90 mm mesh sizes from Çamlığöze Dam Lake in January 2011. Fish samples were transferred to the laboratory to record total body length and total wet weight. Body weight and total length of each individual were measured with a precision of 0.1 g and 0.1 cm, respectively. Fish samples were washed with water, packed in polyethylene bags and stored at  $-20^{\circ}\text{C}$  until analysis. Approximately 1 or 2 g of the gill, kidney, liver, muscle and skin samples were dissected from two fish specimens. The soft tissues were extracted from each fish samples using a plastic knife. After they were individually transferred to 20 ml glass vials previously washed with 0.1 N nitric acid, dried and weighed, they were dried for 24 hours at  $105^{\circ}\text{C}$  and kept in an oven. Then samples were kept at room temperature for 24 hours by adding 3 ml nitric acid. Then samples can withstand heat very low heats on a hot metal plate until the color disappears slowly heated vapors have been mineralized. Then the samples were added to 1 ml sulfuric acid. The samples were added into the 1-2 drops of nitric acid. The digested samples were diluted to 50 ml with distilled water [6-8]. The solution was transferred and filtered through 0.45  $\mu\text{m}$  nitrocellulose membrane filter and ready for analysis [9]. Analysis of the heavy metals in the samples was carried out using a flame atomic absorption spectrophotometer to determine the concentrations of Ag, Cd, Cu, Fe and Pb. The concentrations of Ag, Cd, Cu, Fe and Pb metals were expressed as  $\mu\text{g/g}$  (wet weight). Ag was measured at wavelength 328.100 nm, Cd at 228.802 nm, Cu at 327.393 nm, Fe at 328.204 nm and Pb at 220.353 nm. The values below detection limits were assigned as "ND" in the study.

## 3. Results

A total of two specimens of *S. glanis* were caught from Çamlığöze Dam Lake. Some morphometric characteristics of *S. glanis* from Çamlığöze Dam Lake are given in Table 1. The total length of *S. glanis* population from Çamlığöze Dam Lake ranged from 78.7 to 94.4 cm. The mean total length of all *S. glanis* samples was determined  $86.55 \pm 11.10$ . Weights of *S. glanis* ranged from 1866.2 to 2213.9 g. The mean weight of all *S. glanis* samples was determined  $2040.05 \pm 245.86$  from

Çamlığöze Dam Lake.

Table 1. Some morphometric characteristics of *S. glanis*.

Species	N	Total Length (cm)	Weight (g)
		Mean $\pm$ SD	Mean $\pm$ SD
<i>Silurus glanis</i>	2	$86.55 \pm 11.10$ (78.7–94.4)	$2040.05 \pm 245.86$ (1866.2–2213.9)

N: number of observations, SD: standard deviation, minimum and maximum values are given in parentheses.

The mean concentrations of heavy metals in gill, kidney, liver, muscle and skin of *S. glanis* are summarized in Table 2. Ag, Cd and Cu were detected in all of the examined tissues. Fe and Pb were not detected in all of the examined tissues. The mean heavy metal concentrations were determined in gill as follows; Ag:  $0.038 \pm 0.014 \mu\text{g/g}$ , Cd:  $0.017 \pm 0.001 \mu\text{g/g}$ , Cu:  $0.045 \pm 0.001 \mu\text{g/g}$ . The mean heavy metal concentrations were determined in kidney as follows; Ag:  $0.157 \pm 0.163 \mu\text{g/g}$ , Cd:  $0.020 \pm 0.001 \mu\text{g/g}$ , Cu:  $0.121 \pm 0.021 \mu\text{g/g}$ . The mean heavy metal concentrations were determined in liver as follows; Ag:  $0.048 \pm 0.015 \mu\text{g/g}$ , Cd:  $0.018 \pm 0.005 \mu\text{g/g}$ , Cu:  $0.121 \pm 0.005 \mu\text{g/g}$ . The mean heavy metal concentrations were determined in muscle as follows; Ag:  $0.048 \pm 0.015 \mu\text{g/g}$ , Cd:  $0.016 \pm 0.001 \mu\text{g/g}$ , Cu:  $0.093 \pm 0.076 \mu\text{g/g}$ . The mean heavy metal concentrations were determined in skin as follows; Ag:  $0.052 \pm 0.030 \mu\text{g/g}$ , Cd:  $0.017 \pm 0.001 \mu\text{g/g}$ , Cu:  $0.346 \pm 0.434 \mu\text{g/g}$  from Çamlığöze Dam Lake (Table 2). The patterns of the mean metal occurrence in the selected tissues can be listed as follows in descending order; Silver (Ag): Kidney > Skin > Muscle > Liver > Gill, Cadmium (Cd): Kidney > Liver > Gill = Skin > Muscle and Copper (Cu): Skin > Kidney = Liver > Muscle > Gill in *S. glanis*. The mean concentrations in the tissues of *S. glanis* were found as follows: Cu > Ag > Cd in gill, liver, muscle and skin; Ag > Cu > Cd in kidney.

Generally, the results verify the differences of heavy metal accumulation in different tissues. Concentrations of metals varied depending on different tissues in *S. glanis* from Çamlığöze Dam Lake. The study data showed that, skin accumulated the highest concentration while liver accumulated the lowest. The gill of *S. glanis* had the highest levels of Ag ( $0.048 \mu\text{g/g}$ ), Cd ( $0.018 \mu\text{g/g}$ ) and Cu ( $0.045 \mu\text{g/g}$ ). Similarly, the kidney had the highest levels of Ag ( $0.272 \mu\text{g/g}$ ), Cd ( $0.021 \mu\text{g/g}$ ) and Cu ( $0.135 \mu\text{g/g}$ ). The liver had the highest concentrations of Ag ( $0.048 \mu\text{g/g}$ ), Cd ( $0.021 \mu\text{g/g}$ ) and Cu ( $0.124 \mu\text{g/g}$ ). The muscle had the highest concentrations of Ag ( $0.058 \mu\text{g/g}$ ), Cd ( $0.016 \mu\text{g/g}$ ) and Cu ( $0.146 \mu\text{g/g}$ ). The skin had the highest concentrations of Ag ( $0.073 \mu\text{g/g}$ ), Cd ( $0.018 \mu\text{g/g}$ ) and Cu ( $0.652 \mu\text{g/g}$ ) in *S. glanis*. The highest Ag ( $0.272 \mu\text{g/g}$ ) and Cd ( $0.021 \mu\text{g/g}$ ) concentration was determined in kidney of *S. glanis*. The highest accumulation of Cu was observed in skin with  $0.652 \mu\text{g/g}$  while the lowest accumulation of Cd was observed in liver with  $0.014 \mu\text{g/g}$  in Çamlığöze Dam Lake.

In the fish gill Ag, Cd and Cu concentrations varied between  $0.016 \mu\text{g/g}$  tissue and  $0.048 \mu\text{g/g}$  tissue. The highest concentrations were measured for silver. Similarly, in the fish kidney Ag, Cd and Cu concentrations varied between  $0.019$

µg/g tissue and 0.272 µg/g tissue. The highest concentrations were measured for silver. In the fish liver Ag, Cd and Cu concentrations varied between 0.014 µg/g tissue and 0.124 µg/g tissue. The highest concentrations were measured for copper. In the fish muscle Ag, Cd and Cu concentrations varied between 0.015 µg/g tissue and 0.146 µg/g tissue. The highest concentrations were measured for copper. In the fish skin Ag, Cd and Cu concentrations varied between 0.016 µg/g tissue and 0.652 µg/g tissue (Table 2). The highest concentrations were measured for copper.

#### 4. Discussion

Concentrations of heavy metal varied depending on different tissues. The results of this study indicated that general accumulation of Ag, Cd and Cu in the gill, kidney, liver, muscle and skin of *S. glanis*. The highest accumulation of Ag was observed in kidney with 0.272 µg/g while the lowest accumulation of Ag was observed in gill with 0.028

µg/g. The Ag concentrations in tissues varied from 0.028 µg/g to 0.048 µg/g, mean value of 0.038±0.014 µg/g in gill, 0.041 to 0.272 µg/g, mean value of 0.157±0.163 µg/g in kidney, 0.037 to 0.048 µg/g, mean value of 0.043±0.008 µg/g in liver, 0.037 to 0.058 µg/g, mean value of 0.048±0.015 µg/g in muscle and 0.030 to 0.073 µg/g, mean value of 0.052±0.030 µg/g in skin for *S. glanis* in Çamlığöze Dam Lake (Table 2). Ag is one of the most toxic but least studied of the heavy metals in aquatic ecosystems. Although Ag has received little environmental attention, it is a very toxic metal, it occurs in industrial discharges, and it must be considered in any classification of highly toxic pollutants. Ag in minute amounts in water, is very toxic to fish [10, 11]. The mean Ag values in muscle and liver of *S. glanis* obtained in this study were lower than those obtained by Dirican et al. [11] in *Barbus plebejus*, *Cyprinus carpio* and *Squalius cephalus* from Kılıçkaya Dam Lake, Turkey. There is no information about acceptable limit of Ag in fish tissues.

Table 2. Heavy metals concentrations in tissues of *S. glanis* from Çamlığöze Dam Lake.

Elements	Gill	Kidney	Liver	Muscle	Skin
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Ag	0.038±0.014 (0.028-0.048)	0.157±0.163 (0.041-0.272)	0.043±0.008 (0.037-0.048)	0.048±0.015 (0.037-0.058)	0.052±0.030 (0.030-0.073)
Cd	0.017±0.001 (0.016-0.018)	0.020±0.001 (0.019-0.021)	0.018±0.005 (0.014-0.021)	0.016±0.001 (0.015-0.016)	0.017±0.001 (0.016-0.018)
Cu	0.045±0.001 (0.044-0.045)	0.121±0.021 (0.106-0.135)	0.121±0.005 (0.117-0.124)	0.093±0.076 (0.039-0.146)	0.346±0.434 (0.039-0.652)
Fe	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND

SD: standard deviation, ND: not detected, minimum and maximum values are given in parentheses.

The highest Cd concentration was observed in kidney and liver of *S. glanis* (0.021 µg/g), while the lowest (0.014 µg/g) was in liver. The Cd concentrations in tissues varied from 0.016 µg/g to 0.018 µg/g, mean value of 0.017±0.001 µg/g in gill, 0.019 to 0.021 µg/g, mean value of 0.020±0.001 µg/g in kidney, 0.014 to 0.021 µg/g, mean value of 0.018±0.005 µg/g in liver, 0.015 to 0.016 µg/g, mean value of 0.016±0.001 µg/g in muscle and 0.016 to 0.018 µg/g, mean value of 0.017±0.001 µg/g in skin for *S. glanis* in Çamlığöze Dam Lake (Table 2). The mean Cd values in skin of *S. glanis* obtained in the study were lower than those obtained by Karadede et al. [12] in *S. triostegus* from Atatürk Dam Lake, Turkey. The mean Cd values in gill, kidney and liver of *S. glanis* obtained in the study were lower than those obtained by Jovicic et al. [13] in *S. glanis* from Danube River, Serbia. On the contrary, the mean Cd values in muscle of *S. glanis* obtained in the study were higher than those obtained by Jovicic et al. [13] in the same species from Danube River, Serbia. The mean Cd values in liver and muscle of *S. glanis* obtained in the study were higher than those obtained by Ivanovic et al. [14] in the same species from Danube River, Serbia. The mean Cd values in liver and muscle of *S. glanis* obtained in the study were higher than those obtained by Milanov et al. [15] in the same species from Danube River, Serbia. For Cd (µg/g) Malaysian Food Regulation is 1.00, Hong Kong Environmental Protection Department 2.00 and United States

Food and Drug Administration 3.70 [16-18].

The highest accumulation of Cu was observed in skin with 0.652 µg/g while the lowest accumulation of Cu was observed in muscle and skin with 0.039 µg/g in *S. glanis*. The Cu concentrations in tissues varied from 0.044 µg/g to 0.045 µg/g, mean value of 0.045±0.001 µg/g in gill, 0.106 to 0.135 µg/g, mean value of 0.121±0.021 µg/g in kidney, 0.117 to 0.124 µg/g, mean value of 0.121±0.005 µg/g in liver, 0.039 to 0.146 µg/g, mean value of 0.093±0.076 µg/g in muscle and 0.039 to 0.652 µg/g, mean value of 0.346±0.434 µg/g in skin for *S. glanis* in Çamlığöze Dam Lake (Table 2). The mean Cu values in all of the examined tissues of *S. glanis* obtained in this study were lower than those obtained by Mendil and Uuözlü [19] in *S. glanis* from Ataköy Dam Lake, Turkey. The mean Cu values in gill, liver and muscle of *S. glanis* obtained in the study were lower than those obtained by Ali et al. [20] in *S. glanis* from Ladgo Lake, Cameroun. The mean Cu values in muscle of *S. glanis* obtained in the study were lower than those obtained by Küpeli et al. [21] in the same species from Sakarya River, Turkey. The mean Cu values in gill, kidney, liver and muscle of *S. glanis* obtained in the study were lower than those obtained by Jovicic et al. [13] in the same species from Danube River, Serbia. The mean Cu values in liver and muscle of *S. glanis* obtained in the study were higher than those obtained by Lenhardt et al. [22] in *S. glanis* from Danube River, Serbia. The permissible limits

proposed by the FAO, WHO and Turkish legislation established the following maximum levels for the metals studied, above which consumption is not permitted: 0.1 µg/g for Cd, 5 µg/g for Cu and 0.5 µg/g or 1 µg/g for Pb [23-25]. According to international criteria and Turkish regulation, heavy metal concentrations especially Cd, Cu and Pb in Çamlığöze Dam Lake were found below the permissible levels for examined tissues of *S. glanis*. There is also legislation in other countries regulating the maximum concentration of metals. For example, Spanish legislation limits the levels for Cd at 1 µg/g, Cu at 20 µg/g and Pb at 2 µg/g [26, 27]. According to Spanish legislation limits, heavy metal concentrations Pb in Çamlığöze Dam Lake were below the permissible levels for tissues of *S. glanis*. For Cu (µg/g) Canadian Food Standard is 100, Hungarian standard 60, the range of international standard 10-100 and Turkish Food Codex acceptable limit 20 [28-30]. The comparison showed that our Cu values are lower than the guidelines. A comparison with the European Community food standards [31] for fish Cd: 0.05–0.10 µg/g and Pb: 0.2–0.4 µg/g. According to European Community food standards, heavy metal concentrations Cd and Pb in Çamlığöze Dam Lake were found below the permissible levels for examined tissues of *S. glanis*. These limits were not exceeded in the gill, kidney, liver, muscle and skin of *S. glanis* analyzed in this study.

## 5. Conclusion

These results suggest that *S. glanis* living in Çamlığöze Dam Lake are not heavily burdened with metals. Therefore, conclude that this metals presents no problem for utilization in human consumption of *S. glanis* at this time. Nevertheless, in the future, bioaccumulation of metals, especially Ag, Cd and Cu may emerge a potential risk for the human consumption of this fish. The data obtained in this study bring new knowledge on the Çamlığöze Dam Lake aquatic ecosystem in Turkey. The study provides beneficial information, as studied the fish species also represent major object of commercial fishery in Çamlığöze Dam Lake in Turkey. The current results demonstrate the scientific and practical need for a continuous monitoring of the dynamics of bioaccumulation of heavy metals in *S. glanis* tissue and will serve as a base in further studies in Çamlığöze Dam Lake.

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