

# ANNALES



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## HEAVY METAL CONCENTRATIONS IN TISSUES OF *SIGANUS RIVULATUS* (SIGANIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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### ABSTRACT

Concentrations of heavy metals such as copper (Cu) and lead (Pb) were measured in the liver and muscle tissues of marbled spinefoot *Siganus rivulatus* collected from three main landing areas along the Syrian coast. Muscle tissues always accumulate the lowest concentrations of all metals. In most studied fish, the liver is the target organ for Cu and Pb accumulation. The concentrations of copper in muscle tissues ranged between 0.392 and 0.788 µg/g, in liver between 17.11 and 45.77, lead in muscle tissues from 0.0142 to 0.022 µg/g, and in liver from 0.1 to 0.231 µg/g. The heavy metal with the highest average level recorded in fish is Cu, followed by Cd and Pb. The concentrations of metals in the present fish muscle tissues fell within international legal limits; the fish were thus safe for human consumption.

**Key words:** heavy metals, pollution, liver, muscle tissues, *Siganus rivulatus*, Syrian coast

## CONCENTRAZIONI DI METALLI PESANTI NEI TESSUTI DI *SIGANUS RIVULATUS* (SIGANIDAE) DALLA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

### SINTESI

Le concentrazioni di metalli pesanti come il rame (Cu) e il piombo (Pb) sono state misurate nel fegato e nei tessuti muscolari del pesce coniglio *Siganus rivulatus*, ottenuto in tre zone principali di sbarco lungo la costa siriana. I tessuti muscolari accumulano sempre le concentrazioni più basse di tutti i metalli. Nella maggior parte dei pesci studiati, il fegato è l'organo bersaglio per l'accumulo di Cu e Pb. Le concentrazioni di rame nei tessuti muscolari variavano da 0,392 e 0,788 µg/g, nel fegato da 17,11 a 45,77 µg/g, mentre il piombo nei tessuti muscolari da 0,0142 a 0,022 µg/g, e nel fegato da 0,1 a 0,231 µg/g. Il metallo pesante con il più alto livello medio registrato nei pesci studiati è Cu, seguito da Cd e Pb. Le concentrazioni di metalli nei tessuti muscolari dei pesci analizzati rientravano nei limiti legali internazionali; i pesci erano quindi sicuri per il consumo umano.

**Parole chiave:** metalli pesanti, inquinamento, fegato, tessuti muscolari, *Siganus rivulatus*, costa siriana

## INTRODUCTION

Two species of the genus *Siganus* Forsskål, 1775 occur in the Syrian marine waters, dusky spinefoot *Siganus luridus* (Rüppell, 1829) and marbled spinefoot *S. rivulatus* Forsskål & Niebuhr, 1775 following Saad (2005) and Ali (2018). These two species represent 9% of the total catch by artisanal fisheries and constitute a large part of the total seafood production from Syria (Saad et al., 2016).

Fishes, as a source of protein for local population, are usually at the end of the food chain and considered to be an important zoological group in transferring metals to humans (Aytekin et al., 2019). Bioaccumulation of heavy metals in fish tissues has been the object of previous studies (Saad & Hammoud, 2007; Turan et al., 2009; Abdallah, 2013; Soliman et al., 2021), of which Khaled (2004) and El-Moselhy et al. (2014) also studied the concentrations of heavy metals in different tissues removed from *Siganus rivulatus*.

Similarly, the main goal of the present study was to assess the concentrations of heavy metals such as Pb, Cu, and Cd in muscles and liver of *S. rivulatus* caught by commercial fisheries from three areas located on the coast of Syria.

## MATERIAL AND METHODS

### Study area

The study was conducted between February 2019 and January 2020 on three sites in the Syrian coast (Fig. 1). The first (T1) is located relatively far from any source of industrial pollution ( $34^{\circ}59'46''$  N and  $35^{\circ}53'21''$  E). The second site (T2) was chosen based on its proximity to a thermal power station ( $35^{\circ}10'11''$  N and  $35^{\circ}55'36''$  E). The third site (T3) is an area for the sewage disposal ( $34^{\circ}53'09''$  N and  $35^{\circ}52'57''$  E).

### Fish sampling and analysis

A total of 24 specimens were collected and analyzed. They were immediately placed on ice in an isolated box, transported immediately to the laboratory, and then stored at  $-20^{\circ}$  C until analyzed. The total length of each specimen was recorded to the nearest millimetre and total body weight to the nearest decigram. The liver and a sufficient amount of muscle tissue were removed. The wet digestion method was used for analysis of heavy metals (see Soliman et al., 2021). Samples were transferred into digestion flasks and treated with 5 ml HNO<sub>3</sub> (ultrapure, Merck) on a hot plate until the colour turned to light yellow, nearly white. After this process the samples were transferred to 25 ml flasks and double distilled water was added up to the mark 25 ml. The solution was filtered through filter papers. After digestion, all the

samples were analysed for trace metal (Pb, Cu, and Cd) concentrations using computer controlled Atomic Absorption Spectrophotometer (Spectra AA 220). Accuracy of the employed method was tested against reference material.

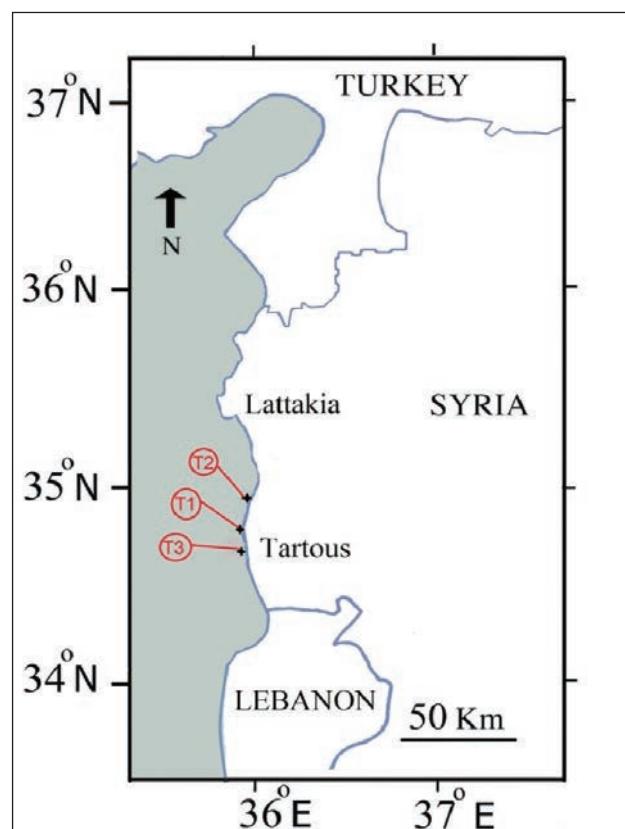
### Statistical analysis

Statistical differences between averages of metal concentrations from different sites were evaluated using one-way ANOVA. The seasonal differences in concentrations were analyzed using Student's *t*-test.

## RESULTS AND DISCUSSION

### Accumulation of metals in organs

Concentrations of heavy metals such as copper (Cu) and lead (Pb) in the livers and muscles of specimens collected from the 3 areas (see Fig. 1) are reported in Table 1. They are significantly higher in



**Fig. 1:** Map indicating the sampling sites in the area of Tartous in the Syrian coast: T1: Off Basira, T2: Off Baniyas, T3: Off Tartous.

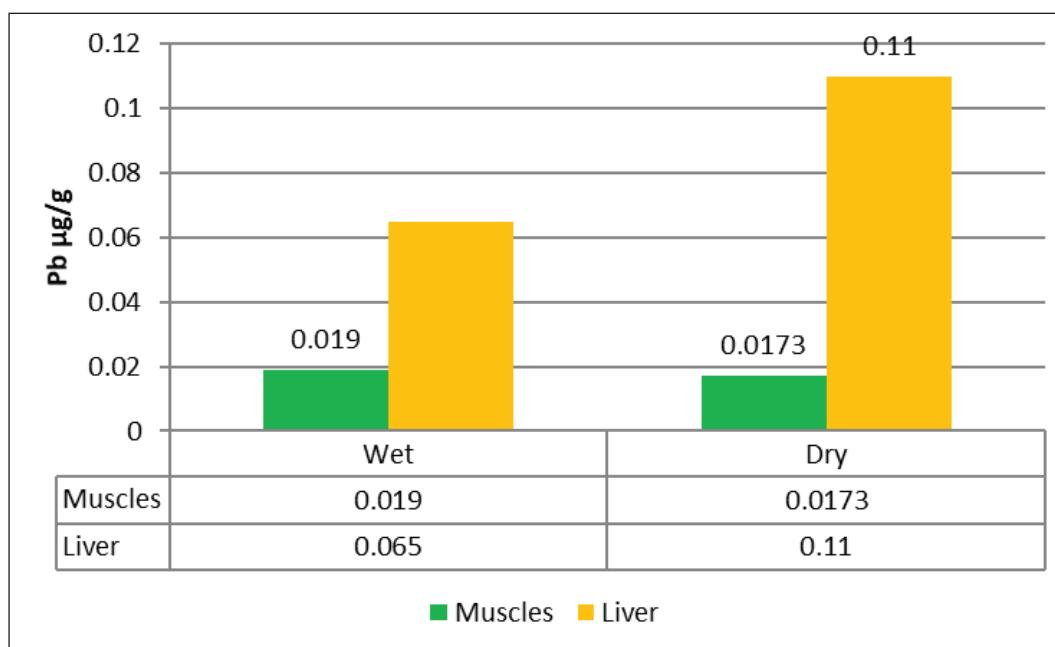
**Sl. 1:** Zemljevid z označenimi vzorčevalnimi postajami na območju Tartousa na sirski obali: T1: Basira, T2: Baniyas, T3: Tartous.

**Tab. 1: Average concentrations of heavy metals ( $\mu\text{g/g}$  wet wt) in various tissues of *Siganus rivulatus* collected from the Syrian coast. Letters a, b, c within each column indicate significant differences among sites (ANOVA  $p < 0.05$ ).**  
**Tab. 1: Povprečne koncentracije težkih kovin ( $\mu\text{g/g}$  mokre mase) v različnih tkivih marmoriranih morskih kuncev (*Siganus rivulatus*), ujetih ob sirski obali. Črke a, b, c v vsakem stolpcu označujejo statistično značilne razlike med mestami (ANOVA  $p < 0,05$ ).**

Tissue	Site	Cu ( $\mu\text{g/g}$ ) Mean $\pm$ SD	Pb ( $\mu\text{g/g}$ ) Mean $\pm$ SD
Muscles	T1	a 0.10 $\pm$ 0.392	0.01425 $\pm$ 0.001 a
	T2	b 0.10 $\pm$ 0.730	0.022 $\pm$ 0.002 c
	T3	b 0.13 $\pm$ 0.788	0.0192 $\pm$ 0.002 b
		Cv = 9% Lsd = 0.061	
Liver	T1	a 6.45 $\pm$ 17.11	a 0.022 $\pm$ 0.1
	T2	c 5.85 $\pm$ 58.56	b 0.033 0 $\pm$ 0.207
	T3	b 5.94 $\pm$ 45.77	0.231 $\pm$ 0.035 b
		Cv = 5.8% Lsd = 3.042	

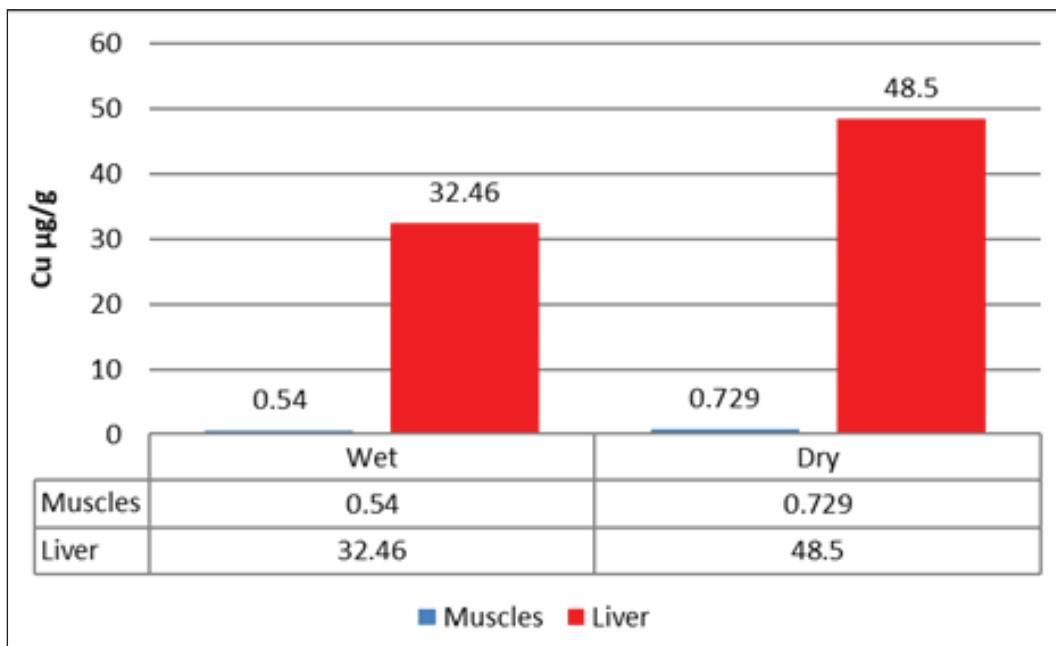
the livers, due to the fact that this organ plays a more important role in the metabolism of fishes (Canli & Atli, 2003; Tepe et al., 2008). Additionally, Kamaruzaman & Jalal (2008) noted that accumulations of Cu

in liver are probably owed to the fact that it plays a physiological role in the metabolism of fishes. Conversely, Pb is non-essential in biochemical processes (Ekong et al., 2006).



**Fig. 2. Changes in Cu concentrations in *Siganus rivulatus* according to season (Wet: winter and spring; Dry: summer and autumn).**

**Sl. 2: Spremembe v vsebnosti Cu pri vrsti *Siganus rivulatus* glede na sezono (Wet: zima in pomlad; Dry: poletje in jesen).**



**Fig. 3. Changes in Pb concentrations in *Siganus rivulatus* according to season (Wet: winter and spring; Dry: summer and autumn).**

**Sl. 3: Spremembe v vsebnosti Cu pri vrsti *Siganus rivulatus* glede na sezono (Wet: zima in pomlad; Dry: poletje in jesen).**

*S. rivulatus* displayed low concentrations of Cu and Pb in muscles, indicating that these organs do not constitute an active site for biotransformation and accumulation of heavy metals (Mohamed, 2008). Similar patterns were reported for 2 fish species, *S. rivulatus* and *Sargus sargus*, collected off Alexandria, in the Mediterranean coast of Egypt (Khaled, 2004).

The highest concentrations of Cu accumulation in the liver ( $58.56 \pm 5.85 \mu\text{g/g}$  wet wt) were found in the *S. rivulatus* from (T2), the lowest ( $17.11 \pm 6.45 \mu\text{g/g}$  wet wt) in those from (T1). Concentrations of Cu in muscles ranged from  $0.392 \pm 0.10$  (T1) to  $0.788 \pm 0.130 \mu\text{g/g}$  wet wt (T3). Such values are probably due to the fact that (T1) is less affected by anthropogenic pollutants than the two other sites. Copper concentrations in muscle tissues found in this study were lower than those reported from Alexandria (Khaled, 2004) and the Red Sea (El-Moselhy et al., 2014) in Egypt. Concentrations of Pb in liver ranged from  $0.1 \pm 0.022$  (T1) to  $0.231 \pm 0.30 \mu\text{g/g}$  wet wt (T3), while concentrations of Pb in muscles ranged from  $0.01425 \pm 0.001$  (T1) to  $0.022 \pm 0.002 \mu\text{g/g}$  wet wt (T2). Lead concentrations in muscle tissues found in this study were lower than those from Alexandria (Khaled, 2004), an area that is more exposed to anthropogenic activities.

#### Seasonal variations in concentrations of metals

There were significant differences in the Cu and Pb accumulated in the white muscles and livers of *S. rivulatus* depending on the season – dry or rainy – when the sampled specimens were collected (Fig. 2).

Mean Cu concentrations in the muscles of the fish from the Syrian coast ranged between  $0.54 \mu\text{g/g}$  in the rainy season and  $0.729 \mu\text{g/g}$  in the dry season, and in the liver between  $32.46 \mu\text{g/g}$  during the rainy season and  $48.50 \mu\text{g/g}$  during the dry season (Fig. 2). The levels of Cu in the muscle and liver tissues were significantly higher in the dry season compared to the rainy season ( $t$ -value = -8.48, 3.27;  $P < 0.001$ ).

Mean Pb concentrations in white muscle and liver tissues of *S. rivulatus* showed significant differences between seasons (Fig. 3), ranging from  $0.017 \mu\text{g/g}$  to  $0.019 \mu\text{g/g}$  ( $t$ -value = 11.18.;  $P < 0.001$ ).

Mean Pb concentrations in the liver ranged from  $0.065 \mu\text{g/g}$  in the rainy and  $0.11 \mu\text{g/g}$  in the dry season (Fig. 3). Pb levels in muscle tissues differed between seasons ( $t$ -value = 4.53.;  $P = 0.004$ ) (Fig. 3). The accumulation of metals in white muscle and liver tissues increased in summer and spring compared to other seasons. Such a pattern may be related to the fact that human activities increase during these

seasons (Hegazi et al., 2015). It could also be due to the rate of metabolism as a consequence of higher temperatures of the sea (Jakimska et al., 2011).

El-Moselhy (2003) noted that seasonal variations in the concentration of heavy metals in marine organisms were also affected by other factors, such as wind, current regimes, monthly salinity variation, as well as the impact of various pollution sources.

The results for *S. rivulatus* showed that metal accumulation during the dry season was significantly higher than during the rainy season, and that Cu and Pb accumulations were higher in the liver than in the muscles (Figs. 2 and 3). Shreadah et al., 2016 also observed increase in Pb concentrations during the summer, which could be a result of human impact and traffic increase. Similar summer increases in metal levels were observed in fish from the coasts of Iskenderun Gulf, Turkey (Aytekin et al., 2019).

#### **Health risk assessment for heavy metal intake through fish consumption**

In this study, the essential heavy metal Cu detected in the livers was above the limits for fish consumption recommended by the Food and Agriculture Organization/World Health Organization (FAO/WHO) and the European Union (EU). Conversely, the non-essential metal Pb in the liver was below the limits for fish consumption recommended by WHO and FAO and was slightly higher than the levels recommended by the European Union (EU). Muscles are the most important part of the fish to be eaten by humans and reflect the concentrations of metals in the water where the fish species lives (Tepa et al., 2008; Can et al., 2020).

In polluted aquatic habitats the concentration of metals in fish muscles can exceed the permissible limits for human consumption and imply severe health threats (Shreadah et al., 2016; Yilmaz et al., 2017; Yilmaz et al., 2018). To assess the public health risk from the consumption of fish from the Syrian coast

**Tab. 2: Maximum permissible limit (MPL) of heavy metals in fish muscles (mg/g wet wt) according to international standards.**

**Tab. 2: Največja dovoljena meja (MPL) vsebnosti težkih kovin v ribjih mišicah (mg/g mokre mase) po mednarodnih standardih.**

References	Metals	
	Cu (µg/g)	Pb (µg/g)
FAO (1983)	30	0.5
FAO/WHO (1989)	30	0.5
WHO (1989)	30	2
European community		0.2

we compared the levels of metal in muscles from the current study (Tab. 1) against existing standards for human consumption established by many different health organizations (Tab. 2).

The mean levels of Cu and Pb in the muscle tissues of *S. rivulatus* were 0.636 µg/g and 0.0185 µg/g, respectively. Similar results were recorded by Khaled (2004) in *S. rivulatus* from Alexandria, Egypt, where the mean Cu and Pb levels ranged between 1.372–1.804 µg/g and 0.182–0.876 µg/g, respectively. El-Moselhy et al. (2014) established the mean levels in *S. rivulatus* from the Red Sea, Egypt at 0.35 µg/g for Cu and 0.44 µg/g for Pb. The same authors suggested that these values were within safe limits for human consumption. According to the results, the fish examined in our study were also within the limits and therefore safe for human consumption. Although, currently, the levels of heavy metals in fish in these regions do not exceed the limits, that may change in the future, depending on the anthropogenic sources from agriculture and industrial development.

## VSEBNOST TEŽKIH KOVIN V TKIVIH MARMORIRANEGA MORSKEGA KUNCA *SIGANUS RIVULATUS* (SIGANIDAE) IZ SIRSKE OBALE (VZHODNO SREDOZEMSKO MORJE)

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### *POVZETEK*

Koncentracije težkih kovin, kot sta baker (*Cu*) in svinec (*Pb*), so bile izmerjene v jetrih in mišičnih tkivih marmoriranih morskih kuncev *Siganus rivulatus*, ujetih blizu treh glavnih pristanišč ob sirske obali. Mišična tkiva vedno kopičijo najnižje koncentracije vseh kovin. Pri večini raziskanih rib so jetra ciljni organ za ugotavljanja kopičenja *Cu* in *Pb*. Koncentracije bakra v mišičnih tkivih so se gibale med 0,392 in 0,788 µg/g in v jetrih med 17,11 in 45,77. Koncentracije svinca v mišičnih tkivih so se gibale od 0,0142 do 0,022 µg/g, v jetrih pa od 0,1 do 0,231 µg/g. Težka kovina z najvišjo povprečno vrednostjo, zabeleženo v ribah, je *Cu*, sledita *Cd* in *Pb*. Koncentracije kovin v ribjih mišičnih tkivih so bile v mejah standardov mednarodnega prava; ribe so bile tako varne za prehrano ljudi.

**Ključne besede:** težke kovine, onesnaževanje, jetra, mišična tkiva, *Siganus rivulatus*, sirska obala

## REFERENCES

- Abdallah, M.** (2013): Bioaccumulation of heavy metals in mollusca species and assessment of potential risks to human health. Bull. Environ. Contam. Toxicol., 90, 552-557.
- Ali, M.** (2018): An updated Checklist of the Marine fishes from Syria with emphasis on alien species. Medit. Mar. Sci., 19(2), 388-393.
- Aytekin, T., D. Kargin, H.Y. Çogun, Ö. Temiz, H.S. Varkal & F. Kargin** (2019): Accumulation and health risk assessment of heavy metals in tissues of the shrimp and fish species from the Yumurtalik coast of Iskenderun Gulf, Turkey. Heliyon, 5(8), e02131.
- Can, M.F., A. B Yılmaz, A. Yanar & E. Kılıç** (2020): Assessment of Accumulation and potential health risk of Cr, Mn, Fe, Cu, and Zn in Fish from North-Eastern Mediterranean Sea. Pollution, 6(3), 597-619.
- Canlı, M. & G. Atlı** (2003): The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. Environ. Pollut., 121, 129-136.
- Ekong, E.B., B.G Jaar & V.M. Weaver** (2006): Lead-related nephrotoxicity: A review of the epidemiological evidence. Kidney Intern., 70, 2074-2084.
- El-Moselhy, K.M.** (2003): Bioacumulation of Metals by Marine Fish "Saurida" from the Different Sites of Egyptian Waters. J. King Abddulaziz Univ. Mar. Sci., 14, 33-51.
- El-Moselhy, K.M., A.I. Othman, H. Abd El-Azem & M.E.A. El-Metwally** (2014): Bioaccumulation of heavy metals in some tissues of fish in the Red Sea, Egypt. Egyp. J. Basic Appl. Sci., 1(2), 97-105.
- Ergül, H.A. & S. Aksan** (2013): Evaluation of non-essential element and micronutrient concentrations in seafood from the Marmara and Black Seas. J. Black Sea/Medit. Environ., 19(3), 312-330.
- European Community** (2005): Commission regulation No 78/ 2005 (pp. L16/43eL16/45). Official J Eur Union 2005 [20.1.2005].
- FAO** (1983): Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fishery Circular No. 464. Food and Agriculture Organization, pp. 5e100.
- FAO/WHO** (1989): Evaluation of certain food additives and the contaminants mercury, lead and cadmium; 1989. WHO Technical Report Series No. 505.
- Hegazi, M.M., A.H. Mostafa, E.H. Assem, H.M. Mourad & S.S. Hasanein** (2015): The effect of seasonal metal pollution in two hotspots (El-Mex, Abu-Qir) Bays on ATPases in gills of *Siganus rivulatus*. Int J Environ Monitor. Anal., 3(5-1), 51-58.
- Jakimaska, A., P. Konieczka, K. Skóra & J. Namiesnik** (2011): Bioaccumulation of metals in tissues of marine animals, Part II: Metal concentrations in animal tissues. Pol. J. Environ. Stud., 20(5), 1127-1146.
- Kamaruzzaman, B.Y., M.C. Ong & K.C.A. Jalal** (2008): Levels of copper, zinc and lead in fishes of Mengabang Telipot River, Terengganu, Malaysia. J. Biol. Sci., 8(7), 1181-1186.
- Khaled, A.** (2004): Seasonal Concentrations of Some Heavy Metals in Muscle Tissues of *Siganus rivulatus* and *Sargus sargus* Fish from El-Mex Bay and Eastern Harbour, Alexandria, Egypt. Egypt. J. Aquat. Biol. Fish, 8, 65-81.
- Mohamed, F.A.S.** (2008): Bioaccumulation of selected metals and histopathological alterations in tissues of *Oreochromis niloticus* and *Lates niloticus* from Lake Nasser, Egypt. Global Vet., 2 (4), 205-218.
- Opute, P., P. Tawari-Fufeyin & E.N. Osaze** (2016): Accumulation of cadmium and the modifying effects of copper and lead in tissues of African snakehead, *Parachanna obscura*. FUW Trends Sci. Technol. J., 1(2), 414-416.
- Saad, A.** (2005): Check-list of bony fish collected from the coast of Syria. Turk. J. Fish. Aquat. Sci., 5(2), 99-106.
- Saad, A. & V. Hammoud** (2007): Levels of mercury, cadmium and lead in the tissue of *Diplodus vulgaris* (Linneus, 1758) (Teleostei Sparidae) from coast of Syria. Rapp. Comm. int. Mer Méditerranée, 38, 308.
- Saad, A., W. Sabour & A. Solaiman** (2017): Contribution to study of the catch effort production of fishing effort by artisanal fishing gears and the qualitative and quantitative composition of the catch in the marine waters of Tartous Governorate. Tichreen Univ. J. Stud. Sci. Res. Bio., 8(1), 12-32.
- Shreadah, M.A., L.M. Abdel Fattah & M.A. Fahmy** (2015): Heavy metals in some fish species and bivalves from the Mediterranean coast of Egypt. J. Environ. Protect., 6(1), 1-8.
- Tepe, Y., M. Türkmen, & A. Türkmen** (2008): Assesment of heavy metals in two commercial fish species of four Turkish Seas. Environ. Monit. Assess., 146, 277-284.
- Turan, C., M. Dural, A. Öksüz & B. Öztürk** (2009): Levels of heavy metals in some commercial fish species captured from the Black Sea and Mediterranean coast of Turkey. Bull. Environ. Contam. Toxicol., 82(5), 601-604.
- Ulman, A., A. Saad, K. Zylich, D. Pauly & D. Zeller** (2015): Reconstruction of Syria's fisheries catches from 1950–2010: signs of overexploitation. Acta Ichthyol. Piscat., 45(3), 259-272.

**WHO (1989):** Heavy metals -environmental aspects; 1989. Environment health criteria. No. 85. Geneva, Switzerland.

**Yilmaz, A., A. Yanar & E.N. Alkan (2017):** Review of heavy metal accumulation on aquatic environment in Northern East Mediterrenean Sea, part I: some essential metals. Rev. Environ. Health, 32(1-2), 119-163.

**Yilmaz, A., A. Yanar & E. N. Alkan (2018):** Review of heavy metal accumulation in aquatic environment of Northern East Mediterrenean Sea part II: Some non-essential metals. Pollution, 4(1), 143-181.