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The concentration of mercury in organs of Whipfin silver biddy (*Gerres filamentosus* Cuv.) and Flathead grey mullet (*Mugil cephalus* L.) in coastal central Vietnam

Introduction

Vietnam is a part of South East Asia bordered by the ocean on the west east and the south, with China to the north and Cambodia and Laos to the west. The coastline stretches over 3.260 km, with an exclusive economic zone (EEZ) of over 1 million km^2 where is a habitat of a vast array of aquatic species (US Department of State, 1983; Pham, Masahide, 2007; Teh et al., 2014). Currently, with the increase in population, urbanization, industrialization, and agricultural practices, pollution with heavy metals in an aquatic ecosystem may occur (Gupta et al., 2009). Mercury (Hg) is one of the most toxic metals in the aquatic ecosystems, which originates both from natural sources and human activities (Luciana et al., 2005; Seyed et al., 2013). Hg cannot be degraded; it is deposited in the aquatic sediments and can be bioaccumulated and biomagnified via the food chain, and finally assimilated by human consumers, which results in health risks (Grimanis et al., 1978; Adams et al., 1992; Ermosele et al., 1995; Smith et al., 1996; Zweig et al., 1999; Agah et al., 2009; Malik et al., 2010).

It is well known that fish play an important role in the human diet. Fish is not only a source of proteins and healthy fats, but it is also a unique source of essential nutrients, including long-chain omega-3 fatty acids, iodine, vitamin D, and calcium (FDA, 2006; Kruzikova et al., 2013; Vicarova et al., 2015). However, it can represent a dangerous source of some heavy metals, especially Hg (Kruzikova et al., 2013).

According to Stankovic et al. (2014), microbes, fungi, plants, animals, and humans are used as bioindicators of heavy metals (including Hg) originating from the air, water, sediment, soil, and the food web. Therefore, fish could be a good and effective indicator of these elements in the aquatic environment. Fish represent a specific level

of the trophic pyramid and links Hg to the ecosystem by bioaccumulation and biomagnification (Stankovic et al., 2014; Łuczyńska et al., 2016)

In this study, two fish species were collected: Whipfin silver biddy and Flathead grey mullet. These species are abundant and an easily accessible resources for artisanal fishing communities and are popular on Vietnam fish markets. There is some published literature on Hg content of these two species in the world (Legorburu et al., 1988; Meng-Hsien Chen, 2002; Yilmaz, 2003; 2005; Chouba et al., 2007; Sih-Wei Huang et al., 2008; Frías-Espericueta et al., 2016; Türkmen et al., 2016; Ruelas-Inzunza et al., 2017; Delgado-Alvarez et al., 2017; Dung et al., 2018), but the data for Vietnam is scarce.

Therefore, the aim of this study was to determine the effect of fish species on Hg concentrations in the selected organs (muscle, liver, and gills) of Whipfin silver biddy and Flathead grey mullet. The data obtained were used to access the level of risk associated with consumption two these fish species in Vietnam. Moreover, the study also evaluates differences between the content of Hg in organs of the same fish.

Material and methods

During July, August, and September 2017, fish samples were obtained from local fishermen and the fish market of coastal Vietnam of Nghe An, Ha Tinh, Quang Binh, Quang Tri and Hue. Two fish species were collected as Whipfin silver biddy – *Gerres filamentosus* Cuv. (n = 28) and Flathead grey mullet – *Mugil cephalus* L. (n = 48). The muscle tissue from the dorsal area, the liver, and gill tissue were collected, placed in labelled polypropylene bags and stored at -20°C until analysis.

Total mercury concentrations in samples were determined by cold vapour atomic absorption spectrometry (NIC, MA-2; limit of quantification was 0.2 ng per sample). Data was presented in $\mu g\ g^{-1}$ wet weight.

The one-way analysis of variance ANOVA and Duncan's test was used to test significant interspecific differences in the content of mercury both between species and the organs of the same species. Statistical significance was declared when the p value was equal to or less than 0.05.

Results and discussion

The highest Hg concentrations in Flathead grey mullet were found in the liver, followed by muscle and gills (0.195, 0.097 and 0.046 $\mu g\ g^{-1}$ w.w., respectively – Tab.1).

Tab. 1. Mercury concentrations (μg g^{-1} wet weight) in gills, liver, and muscle of Flathead grey mullet (n = 48)

Tissue	Mean	±SD	Min	Max
Gills	0.046	0.016	0.015	0.075
Liver	0.195	0.101	0.063	0.494
Muscle	0.097	0.037	0.027	0.184

Note: SD – standard deviation, Min – minimum, Max – maximum

There are several studies of Hg concentrations of Flathead grey mullet available in the literature. Mostly, the concentrations reported are lower than the mean value found in this study (Sankar et al., 2006; Dural et al., 2007; Ruelas-Inzunza et al., 2008; Sih-Wei Huang et al., 2008; Squadrone et al., 2013; Ruelas-Inzunza et al., 2017). However, there were also some reported Hg concentration higher than the mean we obtained (Chouba et al., 2007; Frías-Espericueta et al., 2016) (Tab. 2).

Tab. 2. Mean total Hg concentrations (μg g^{-1} wet weight) in Flathead grey mullet

Mean Hg concentration			Location	References
Gills	Liver	Muscle		
0.046	0.195	0.097	Central Vietnam	This study
-	0.050	0.032	California US State	Ruelas-Inzunza et al. (2017)
-	0.503	0.036	Northwestern Mexico	Frías-Espericueta et al. (2016)
-	-	< 0.025	Mediterranean sea	Squadrone et al. (2013)
-	-	0.016	Northwestern Mexico	Ruelas-Inzunza et al. (2008)
-	0.044	0.110	Tainan, Taiwan	Sih-Wei Huang et al. (2008)
-	-	0.025	Mediterranean sea	Dural et al. (2007)
-	0.242	0.098	Tunisian lagoon (Winter)	Chouba et al. (2007)
-	0.235	0.084	Tunisian lagoon (Spring)	Chouba et al. (2007)
-	0.231	0.056	Tunisian lagoon (Summer)	Chouba et al. (2007)
-	0.247	0.102	Tunisian lagoon (Autumn)	Chouba et al. (2007)
-	-	0.040	Calicut, India	Sankar et al. (2006)

Tab. 3. Mercury concentrations (μg g^{-1} wet weight) in gills, liver, and muscle of Whipfin silver biddy (n = 28)

Tissue	Mean	±SD	Min	Max
Gills	0.077	0.040	0.036	0.220
Liver	0.245	0.187	0.078	0.643
Muscle	0.460	0.200	0.233	1.095

Note: SD – standard deviation, Min – minimum, Max – maximum

Concentrations of Hg in gills, liver, and the muscle of Whipfin silver biddy differed between themselves (Tab. 3). The highest mean was noted in muscles (0.460 μg g^{-1} w.w), followed by the liver and gills (0.245 and 0.077 μg g^{-1} w.w, respectively). In this study, Hg accumulation in muscles and the liver was higher than previously reported

by Meng-Hsien Chen (2002), Sih-Wei Huang et al. (2008), and Dung Le Quang et al. (2018). According to Meng-Hsien Chen (2002), Hg concentrations in muscles and livers of Whipfin silver biddy were both 0.025 μg g^{-1} w.w..In muscles, Sih-Wei Huang (2008) recorded 0.45 μg g^{-1} w.w., and Dung Le Quang (2018) recorded 0.358 μg g^{-1} w.w.

There were significant differences in mercury contents in muscles and gills between both species in this study ($p<0.05$). However, there was no difference in the concentration of Hg in livers between Flathead grey mullet and Whipfin silver biddy (Tab. 4).

Tab. 4. Differences in Hg concentration (μg g^{-1} wet weight) between the organs of both species

Tissue	Species	Mean	Statistical results (p)	±SD	Min	Max
Gills	Whipfin silver biddy	0.077	0.000	0.040	0.036	0.220
	Flathead grey mullet	0.046		0.016	0.015	0.075
Liver	Whipfin silver biddy	0.245	0.132	0.200	0.233	1.095
	Flathead grey mullet	0.195		0.037	0.027	0.184
Muscle	Whipfin silver biddy	0.460	0.000	0.187	0.078	0.643
	Flathead grey mullet	0.097		0.101	0.063	0.494

Note: SD – standard deviation, Min – minimum, Max – maximum

The mean Hg concentrations determined in this study for Flathead grey mullet are one order of magnitude lower than the maximum permissible threshold (0.5 μg/g w.w. = 2 μg/g d.w.; FAO-WHO, 2003; *Ministry of Health of Vietnam*, 2007), which suggests wide limits of safety for the consumption of these fish species. It is not the same in the case of Whipfin silver biddy, because the Hg concentration (0.460 μg g^{-1} w.w) in the muscle of this species almost reached the maximum permissible level.

The result of this study agree with the views of Türkmen et al. (2011; 2016) and Azevedo et al. (2012), which describe that, in most fish species, the liver is the main storage place for metals. However, this is not a general rule in the case of Hg. We detected higher content of Hg in muscle than in liver in Whipfin silver biddy, as did Coelho et al. (2010) and Polack-Juszczak (2015). Additionally, Waltham et al. (2013) and Diop and Amara (2016) found no differences between Hg concentrations in livers and muscles of some fish species.

The difference in Hg concentration in organs of fish between the two species may be explained by several factors, such as resident time, trophic transfer, growth rate, prey type, and dietary quality. All of them can affect the Hg bioaccumulation in fish communities (Hall et al., 1997; Marugo-Negrete et al., 2008). Among others factors, feeding habits have been recognised as a prime reason for Hg contamination (Hall et al., 1997).

Conclusions

Statistically significant differences in mean Hg levels were observed between two fish species investigated (Whipfin silver biddy – *Gerres filamentosus* Cuv. and Flathead grey mullet – *Mugil cephalus* L.) and their tissues, (except for their livers, there is no statistical difference between the two observed species). These results supply information on Hg contents in tissues of the species examined in coast central Vietnam and indirectly indicate Hg levels in the marine environment. These results can be used to understand the chemical quality of fish and to evaluate the possible risk associated with their consumption.

References

Adams, W.J., Kimerle, R.A., Barnett, J.W. (1992). Sediment quality and aquatic life assessment. *Environmental Science and Technology*, *26*, 1865–1875.

Agah, H., Leermakers, M., Elskens, M., Fatemi, S.M.R., Baeyens, W. (2009). Accumulation of trace metals in the muscles and liver tissues of fve fish species from the Persian Gulf. *Environmental Monitoring Assessment*, *157*, 499–514. DOI: 10.1007/s10661-008-0551-8.

Azevedo, J.S., de Souza-Sarkis, J.E., Oliveira, T.A., Ulrich, T. (2012). Tissue-specific mercury concentrations in two catfish species from the Brazilian coast. *Brazilian Journal of Oceanography*, *60*, 211–219. DOI: 10.1590/S1679-87592012000200011

Chouba, L., Kraiem, M., Njimi, W., Tissaoui, C.H., Thompson, J.R., Flower, R.J. (2007). Seasonal variation of heavy metals (Cd, Pb and Hg) in sediments and in mullet, *Mugil cephalus* (Mugilidae), from the Ghar El Melh Lagoon (Tunisia). *Transitional Waters Bulletin*, *4*, 45–52. DOI: 10.1285/i1825229X-v1n4p45

Coelho, J.P., Santos, H., Reis, A.T., Falcão, J., Rodrigues, E.T., Pereira, M.E., Duarte, A.C., Pardal, M.A. (2010). Mercury bioaccumulation in the spotted dogfish (*Scyliorhinus canicula*) from the Atlantic Ocean. *Marine Pollution Bulletin*, *60*, 1372–1375. DOI: 10.1016/j.marpolbul.2010.05.008

Delgado-Alvarez, C.G., Frías-Espericueta, M.G., Ruelas-Inzunza, J., Becerra-Álvarez, M.J., Osuna-Martínez, C.C., Aguilar-Juárez, M., Osuna-López, J.I., Escobar-Sánchez, O., Voltolina, D. (2017). Total mercury in muscles and liver of Mugil spp. from three coastal lagoons of NW Mexico: concentrations and risk assessment. *Environmental Monitoring and Assessment*, *189*, 312. DOI: 10.1007/s10661-017-6020-5

Diop, M., Amara, R. (2016). Mercury concentrations in the coastal marine food web along the Senegalese coast. *Environmental Science and Pollution Research*, *23*, 11975–11984. DOI: 10.1007/s11356-016-6386-x

Dung Le, Q., Satyanarayana, B., Siau, Y., F., Kotaro, S. (2018). Mercury bioaccumulation in tropical mangrove wetland fishes: Evaluating potential risk to coastal wildlife. *Biological Trace Element Research*, 1–8. DOI: 10.1007/s12011-018-1313-2

Dural, M., Goksu, M., Ozak, A. (2007). Investigation of heavy metal levels in economically important fish species captured from the Tuzla lagoon. *Food Chemistry*, *2*, 415–421. DOI: 10.1016/j.foodchem.2006.03.001

Ermosele, C.O., Ermosele, I.C., Murktar, S.A., Birdling, S.A. (1995). Metals in fish from the upper Benue River and lakes Geryo and Njuwa in northern Nigeria. Bull. *Environmental Contamination and Toxicology*, *54*, 8–14.

FAO-WHO (2003). Summary and conclusions of the sixty-first meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA), Annex 4. JECFA/61/SC. http://ftp.fao.org/es/esn/jecfa/jecfa61sc.pdf.

FDA (2006). Mercury levels in commercial fish and shellfish. Washington DC. www.cfsan.fda.gov/~frf/sea-mehg.html.

Frías-Espericueta, M.G., Vargas-Jiménez, A., Ruelas-Inzunza, J., Osuna-López, J.I., Aguilar-Juárez, M., Bautista-Covarrubias, J.C. (2016). Total mercury in mugil spp and Eugerres axillaris of a subtropical lagoon of NW Mexico. *Bulletin of Environmental Contamination and Toxicology*, *97(2)*, 211–215. DOI: 10.1007/s00128-016-1811-x

Grimanis, A.P., Zafiropoulos, D., Vassilaki, R., Grimanis, M. (1978). Trace elements in the flesh and liver of two fish species from polluted and unpolluted areas in the Aegean Sea. *Environmetnal Science and Technology*, *12*, 723–726. DOI: 10.1021/es60142a001

Gupta, A., Rai, D.K., Pandey, R.S., Sharma, B. (2009). Analysis of some heavy metals in the river in water, sediments and fish from river Ganges at Allahabad. *Environmental Monitoring Assessment*, *157*, 449–458. DOI: 10.1007/s10661-008-0547-4

Hall, B.D., Bodaly, R.A., Fudge, R.J.P., Rudd, J.W.M., Rosenberg, D.M. (1997). Food as the dominant pathway of methylmercury uptake by fish. *Water, Air, Soil Polluttion*, *100*, 13–24.

Kruzikova, K., Kensova, R., Sedlasckova, E., Jarkovsky, J., Poleszczuk, G., Svobodová, Z. (2013). The correlation between fish mercury liver/muscle ratio and high and low levels of mercury contamination in Czech localities. *International Journal of Electrochemistry Science*, *8*, 45–56.

Legorburu, I., Canton, L., Millan, E., Casado, A. (1988). Trace metal levels in fish from Unda river (Spain) Anguillidae, Mugillidae and Salmonidae. *Environmental Technology Letters*, *41*, 1373–1378. DOI: 10.1080/09593338809384703

Farias, L.A., Azevedo, J., Fávaro, D.,I., Braga, E.S. (2005). Evaluation of mercury, selenium and methylmercury in fish consumed by Santos Bay communities, São Paulo, Brazil. *International Nuclear Atlantic Conference* – INAC, *36*, 9.

Łuczyńska, J., Łuczyński, M.J., Paszczyk, B. (2016). Assessment of mercury in muscles, liver and gills of marine and freshwater fish. *Journal of Elements*, *21(1)*, 113–129. DOI: 10.5601/jelem.2015.20.2.879

Malik, N., Biswas, A.K., Qureshi, T.A., Borana, K., Virha, R. (2010). Bioaccumulation of heavy metals in fish tissues of a freshwater lake of Bhopal. *Environmental Monitoring Assessment*, *160*, 267–276. DOI: 10.1007/s10661-008-0693-8

Marrugo-Negrete, J., Verbel, J.O., Ceballos, E.L., Benitez, L.N. (2008). Total mercury and methylmercury concentrations in fish from the Mojana region of Colombia. *Environmental Geochemistry and Health*, *30(1)*, 21–30. DOI: 10.1007/s10653-007-9104-2

Meng-Hsien, Ch. (2002). Baseline metal concentrations in sediments and fish, and the determination of bioindicators in the subtropical Chi-ku Lagoon, S.W. Taiwan. *Marine Pollution Bulletin*, *44*, 703–714. DOI: 10.1016/S0025-326X(02)00066-8

Ministry of Health of Vietnam (2007). Prescribed maximum limit of chemical and biological contamination in food, Decision 46/2007/QD-BYT 19/12, p 26.

Pham, T.T.H., Masahide, F. (2007). Impact of sea level rise on coastal zone of Vietnam. *Bulletin of the Facaculty of Science, University of Ryukus*, *84*, 45–59.

Polack-Juszczak, L. (2015). Selenium and mercury molar ratios in commercial fish from the Baltic Sea: additional risk assessment criterion formercury exposure. *Food Control*, *50*, 881–888. DOI: 10.1016/j.foodcont.2014.10.046

Ruelas-Inzunza, J., Meza-López, G., Páez-Osuna, F. (2008). Mercury in fish that are of dietary importance from the coasts of Sinaloa (SE gulf of California). *Journal of Food Composition and Analysis*, *21*, 211–218. DOI: 10.1016/j.jfca.2007.11.004

Ruelas-Inzunza, J., Kohen-Sandoval, C.K., Ramos-Osuna, M.A., Sánchez-Osuna, K.G., Spanopoulos-Zarco, P., Delgado-Alvarez, C.G., Amezcua-Martínez, F. (2017). Total mercury concentrations in white and striped Mullet (*Mugil curema* and *M. cephalus*) from a coastal lagoon in the SE Gulf of California. *Journal of Environmental Science and Health*, Part A., *52(5)*, 459–465. DOI: 10.1080/10934529.2016.1271670

Sankar, T.V., Zynudheen, A.A., Anandan, R., Viswanathan, P.G. (2006). Distribution of organochlorine pesticides and heavy metal residues in fish and shellfish from Calicut region, Kerala, India. *Chemosphere*, *65*, 583–590. DOI: 10.1016/j.chemosphere.2006.02.038

Seyed, M.H., Noorollah, M., Nasrollah, M.S., Seyed, V.H., Amir, F.G. (2013). Risk assessment of the total mercury in Golden gray mullet (*Liza aurata*) from Caspian Sea. *International Journal of Aquatic Biology*, *1(6)*, 258–265.

Sih-W., Huang, Chen, Ch.-Y., Chen, M.-H. (2008). Total and organic Hg in fish from the reservoir of a chlor-alkali plant in Tainan, Taiwan. *Journal of Food and Drug Analysis*, *16(2)*, 75–80.

Smith, C.J., Hotmans, O., Cook, F.N. (1996). Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with treated effluent in Australia. *Journal of Environmental Pollutution*, *94*, 317–323. DOI: 10.1016/S0269-7491(96)00089-9

Squadrone, S., Prearo, M., Brizio, P., Gavinelli, S., Pellegrino, M., Scanzio, S. (2013). Heavy metals distribution in muscle, liver, kidney and gill of European catfish (*Silurus glanis*) from Italian rivers. *Chemosphere*, *90*, 358–365. DOI: 10.1016/j.chemosphere.2012.07.028

Stankovic, S., Kalaba, P., Stankovic, A.R. (2014). Biota as toxic metal indicators. *Environmental Chemical Letters*, *12*, 63–84. DOI: 10.10007/s10311-013-0430-6

The, L., Zeller, D., Zylich, K., Nguyen, G., Harper, S. (2014). *Reconstructing Vietnam's marine fisheries catch, 1950-2010*. Fisheries Centre, University of British Columbia, 2014–2017, 11p.

Türkmen, A., Tepe, Y., Türkmen, M. (2016). Determination of metals in tissues of fish species from Hurmaboğazı lagoon. *Indian Journal of geo-Marine Sciences*, *45*, 277–282.

Türkmen, M., Türkmen, A., Tepe, Y. (2011). Comparison of metals in tissues of fish from Paradeniz Lagoon in the coastal area of northern East Mediterranean. *Bulletin of Environmental Contamination and Toxicology*, *87*, 381–385. DOI: 10.1007/s00128-011-0381-1

US Department of State (1983). Limits in the Seas. Straight baselines: Vietnam, *99*, 5–6.

Vicarova, P., Pelcova, P., Kleckerova, A., Mares, J., Kopp, R., Postulkova, E., Docekalova, H. (2015). Distribution of mercury in tissues of the Common Carp (*Cyprynus carpio* L.). *MendelNet*, 500–505.

Waltham, N.J., Teasdale, P.R., Connolly, R.M. (2013). Use of flathead mullet (*Mugil cephalus*) in coastal biomonitor studies: review and recommendations for future studies. *Marine Pollution Bulletin*, *69*, 195–205. DOI: 10.1016/j.marpolbul.2013.01.012

Yilmaz, A.B. (2003). Levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in tissue of *Mugil cephalus* and *Trachurus mediteraneus* from Iskenderun bay, Turkey. *Environmental Research*, *92*, 277–281. DOI: 10.1016/S0013-9351(02)00082-8

Yilmaz, A.B. (2005). Comparison of heavy metal levels of Grey Mullet (*Mugil cephalus* L.) and sea bream (*Sparus aurata* L.) caught in Iskendrun Bay (Turkey). *Turkish Journal of Veterinary and Animal Sciences*, *29*, 257–262.

Zweig, R.D., Morton, J.D., Stewart, M.M. (1999). *Source water quality for aquaculture: A guide for assessment*. Washington DC: The World Bank, 23–24.

Abstract

The concentration of mercury (Hg) in fish species has direct consequences on the health of humans and the ecosystem. Thus, in this paper, the accumulation of Hg in gills, livers, and muscles of two fish species (Whip-

fin silver biddy – *Gerres filamentosus* and Flathead grey mullet – *Mugil cephalus*) were measured by cold vapour atomic absorption spectrometry. The fish specimens were collected from local markets and direct fishing with the help of fishermen over the period from July to September 2017 in coastal Vietnam. Differences in the total Hg were found both between two species and organs. The concentration of Hg in all organs investigated of Whipfin silver biddy was higher than of Flathead grey mullet ($p < 0.05$). The content of Hg in the muscles of Whipfin silver biddy was higher than in the livers and gills ($p < 0.05$), 0.460, 0.245, 0.077 μg g^{-1} w.w., respectively. Livers of Flathead grey mullet had more Hg accumulated than did the muscles and gills (0.195, 0.097, 0.046 μg g^{-1} w.w., respectively). The results revealed that Hg concentrations in Flathead grey mullet did not exceed food fish safety limits established for human consumption, while the concentration of this toxic element in the muscles of Whipin silver biddy almost reached the maximum permissible level.

Keywords: Coastal Vietnam, *Gerres filamentosus*, *Mugil cephalus*, mercury

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Stężenia rtęci w organach pobranych od *Gerres filamentosus* (Cuv.) i *Mugil cephalus* (L.) z Wietnamu

Streszczenie

Akumulacja rtęci (Hg) w rybach ma (duże, choć pośrednie) bezpośrednie znaczenie dla zdrowia ludzi i ekosystemu. Dlatego w tym projekcie zbadano stężenia Hg w skrzelach, wątrobie i mięśniach dwóch gatunków ryb (*Gerres filamentosus* i *Mugil cephalus*). Badania przeprowadzono z wykorzystaniem techniki atomowej spektrometrii absorpcyjnej z przystawką zimnych par. Osobniki ryb zostały (kupione) pozyskane na lokalnych targach lub bezpośrednio od rybaków w okresie między lipcem a wrześniem 2017 r. w Wietnamie. Różnice w stężeniach rtęci były obserwowane zarówno między badanymi gatunkami, jak i tkankami (materiałami). Stężenia Hg wykryte we wszystkich materiałach pobranych od *Gerres filamentosus* były wyższe niż w materiałach pobranych od *Mugil cephalus* ($p < 0,05$). Stężenia Hg w mięśniach *Gerres filamentosus* były wyższe niż w wątrobie i skrzelach ($p < 0,05$), odpowiednio 0,460, 0,245 i 0,077 μg g^{-1} m.m. (mokrej masy). Wątroba *Mugil cephalus* zakumulowała wyższe stężenia Hg niż mięśnie i skrzela (odpowiednio 0,195; 0,097 i 0,046 μg g^{-1} m.m. Wyniki wskazują, że stężenia rtęci u *Mugil cephalus* (badanych gatunków) nie przekraczają norm ustalonych dla żywności do spożycia przez ludzi. Jednak poziom Hg w mięśniach Gerras filamentosus jest zbliżony do tej wartości, co stanowi pewne zagrożenie dla potencjalnych konsunentów.

Słowa kluczowe: Wietnam, *Gerres filamentosus*, *Mugil cephalus*, rtęć

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