Electronic Supplementary Material

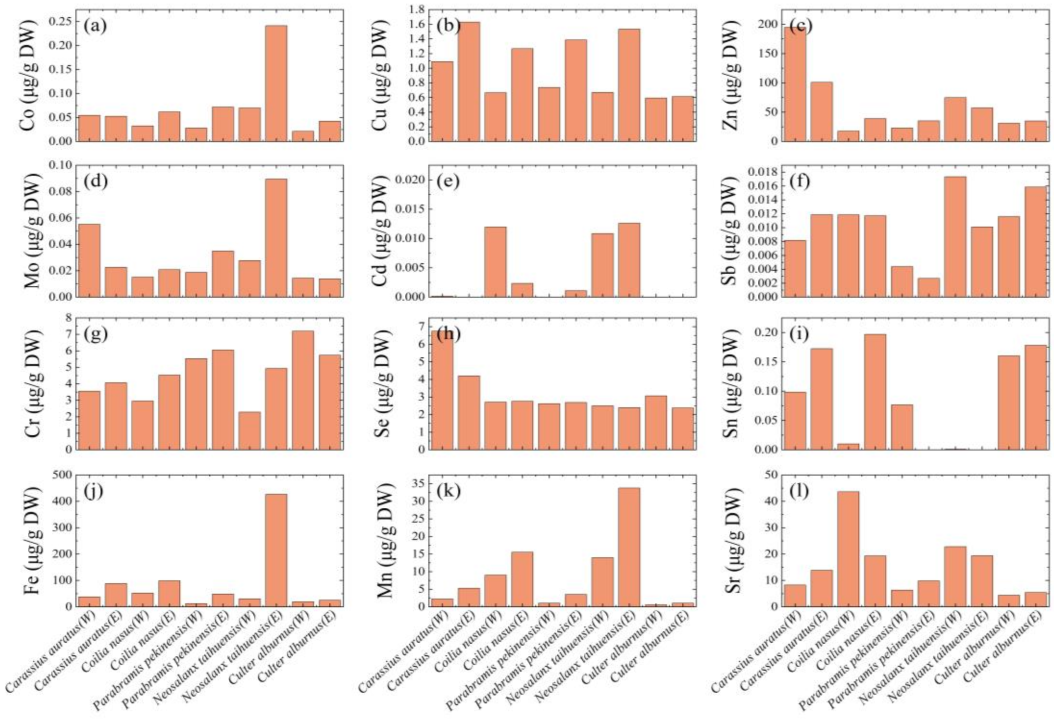

Fig. S1 The spatial distribution of trace elemental concentrations (μg/g DW) in different fish species of lake area.

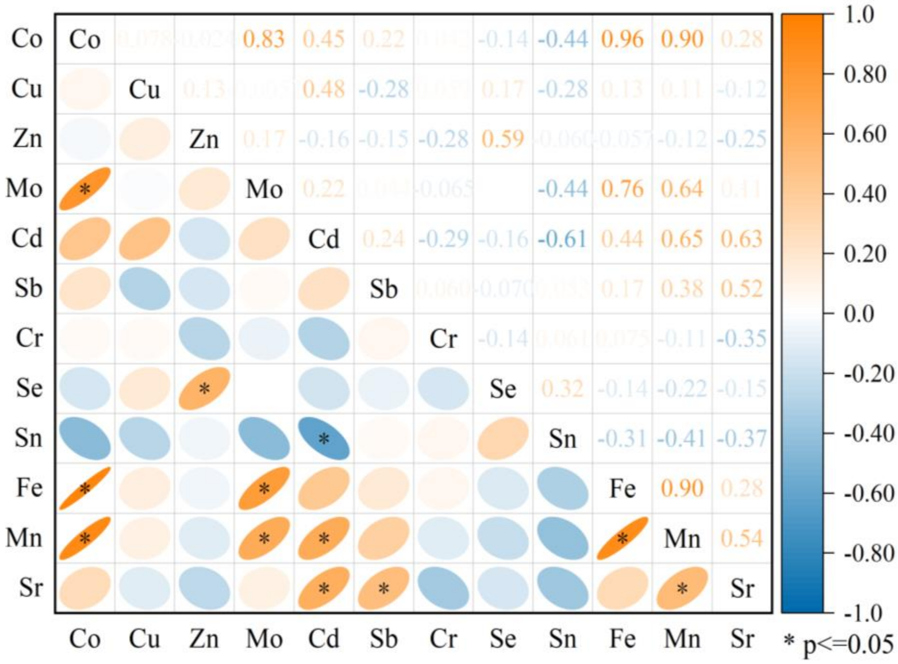

Fig. S2 The correlation analysis of trace element in fish.

Table S1 Indicators used in species of Zn in the process of PHREEQC simulation.

Index	R1	R2	R3	R4	R5	L1	L2	L3	L4	L5	L6	L7
pH	8.07	9.25	8.59	8.21	8.49	9.01	8.65	8.69	8.67	8.7	8.33	8.61
T	34.9	36.5	36.8	34	36.4	17.8	20.8	15.6	16.4	15.5	16.3	15.9
Zn(μg/L)	0.2500	0.6790	0.4250	0.2500	0.2500	5.6400	4.5560	4.4180	4.3710	4.1160	4.2890	3.9950
Li^{+}(mg/L)	0.0001	0.0010	0.0004	0.0002	0.0001	0.0013	0.0000	0.0000	0.0003	0.0007	0.0004	0.0000
Na^{+}(mg/L)	32.8624	107.7578	82.6267	60.4588	57.5070	97.9322	71.4448	65.1932	61.6002	61.9415	67.6405	65.5912
NH_4^{+}(mg/L)	0.0009	0.0000	0.0064	0.0000	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024
K^{+}(mg/L)	0.0396	0.4816	0.3142	0.0613	0.1978	1.3833	0.1716	0.2253	0.4883	0.6077	0.2844	0.0270
Mg^{2+}(mg/L)	0.0515	0.5076	0.3521	0.0717	0.1386	0.6808	0.1025	0.2510	0.6208	0.5643	0.2148	0.0668
Ca^{2+}(mg/L)	0.1587	2.0155	1.2757	0.1806	0.5402	2.3215	0.2911	0.9311	2.4588	2.1297	0.6341	0.1258
F^{-}(mg/L)	0.3258	0.5166	0.5441	0.4937	0.5563	0.3689	0.3039	0.3672	0.3691	0.3668	0.3846	0.3771
BrO_3^{-}	0.0000	0.0000	0.0000	0.1265	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cl^{-}(mg/L)	10.5072	40.6611	34.9736	16.0342	25.8087	52.6192	34.5439	28.9313	26.5885	26.2632	27.9067	26.8455
NO_2^{-}(mg/L)	0.1122	0.0000	0.1448	0.0892	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Br^{-}(mg/L)	0.0000	0.2520	0.0000	0.2252	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NO_3^{-}(mg/L)	5.1604	10.7691	9.1297	4.3887	6.0369	12.3100	8.7210	6.3388	4.1761	4.6071	4.9785	4.2566
SO_4^{2-}(mg/L)	0.0000	0.0000	0.0000	0.0000	0.0000	36.6626	25.4586	22.9792	21.5893	20.9362	22.9921	21.0828

Table S2 The mean concentrations and coefficient of variation of TEs in fish in Chaohu Lake Basin.

Elements	River		Lake	
	Mean concentrations (μg/g DW)	Coefficient of variation	Mean concentrations (μg/g DW)	Coefficient of variation
Co	0.029	16.20%	0.068	93.94%
Cu	1.495	103.22%	1.019	40.22%
Zn	80.807	63.23%	60.848	87.87%
Mo	0.021	84.37%	0.031	76.70%
Cd	0.003	223.61%	0.004	141.50%
Sb	0.003	88.66%	0.011	43.03%
Cr	3.871	32.39%	4.683	32.20%
Se	3.112	36.78%	3.207	42.12%
Sn	0.131	90.65%	0.089	92.64%
Fe	35.651	40.77%	83.906	147.39%
Mn	1.937	58.31%	8.598	120.58%
Sr	4.461	23.50%	15.319	77.51%

Table S3 Total concentration of trace elements in freshwater fish muscles worldwide (μg/g DW).

		As	Cr	Mn	Fe	Ni	Cu	Zn	Cd	Se	
China	Chaohu Lake	0.412	4.292	6.096	75.510	0.551	1.243	62.327	0.007	3.058	This study
	Chaohu Lake		2.839			0.150	2.438	96.038	0.175		Yin et al., 2018
	Tai Lake	0.338	0.558	4.993	29.141			92.400	0.037		Chen et al., 2013
	Dongting Lake	0.480	1.010		4.614	0.479	0.683	18.227	0.007	1.020	Jiang et al., 2022
	Yangtze River	0.100	1.077				12.856	46.958	0.709		Yi et al., 2011
	Yellow River	0.388	1.235						0.053		Ai et al., 2022
	Pearl River	0.928	15.355						0.628		
	Huai River	0.145	1.575						1.598		
	Southeast basin	0.158	0.200						0.015		
	China	0.228	0.310						0.034		
Other countries	Bangladesh	1.040	0.760				4.970		0.110		Ahmed et al., 2019
	South Africa	<0.02	0.105				1.963	19.925	0.025	1.757	C. Plessl et al., 2019
	Poland	5.660	0.680			6.800	2.110	0.730			Szara-Bak et al., 2021
	Turkey	0.291	0.061		6.700	0.039	0.358	6.600	0.003		Varol et al., 2022
	France	0.410							0.025		Noël et al., 2013
	India		3.480				15.750	85.735	2.995		Maurya et al., 2019
	Peru	0.205					1.070	12.715			Condor et al., 2021

Table S4 Original results of mass molality of Zn species output by PHREEQC model.

	BAF	Mass molality														
	Zn	Zn^{2+}	$ZnOH^{+}$	$Zn(OH)_2$	$Zn(OH)_3^{-}$	$Zn(OH)_4^{2-}$	$ZnCl^{+}$	ZnOHCl	ZnF^{+}	$ZnCl_2$	$ZnCl_3^{-}$	$ZnCl_4^{2-}$	$ZnBr^{+}$	$ZnBr_2$	$ZnSO_4$	$Zn(SO_4)_2^{2-}$
Cyprinus carpio (HB)	41043.92	2.75E-09	6.56E-10	4.12E-10	1.59E-13	3.31E-18	2.89E-12	2.63E-12	6.47E-13	8.63E-16	3.04E-19	5.25E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cyprinus carpio (ZG)	62031.66	2.42E-09	7.28E-10	6.66E-10	3.58E-13	1.06E-17	3.60E-12	4.66E-12	8.23E-13	1.61E-15	8.60E-19	2.29E-22	1.49E-15	1.52E-21	0.00E+00	0.00E+00
Cyprinus carpio Cyprinus carpio (NF)	15581.49	1.92E-09	1.64E-09	2.91E-09	3.80E-12	2.79E-16	6.70E-12	1.83E-11	7.11E-13	6.44E-15	7.63E-18	4.62E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cyprinus carpio (Z)	60830.86	1.43E-09	9.65E-10	1.42E-09	1.45E-12	8.26E-17	3.75E-12	8.35E-12	5.58E-13	2.70E-15	2.36E-18	1.03E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cyprinus carpio (SWL)	48908.2	2.90E-10	1.08E-09	8.94E-09	5.37E-11	1.84E-14	1.13E-12	1.42E-11	9.88E-14	1.24E-15	1.71E-18	1.22E-21	1.86E-16	2.05E-22	0.00E+00	0.00E+00
Carassius auratus (W)	8549.228	2.08E-08	6.22E-09	4.16E-08	6.23E-11	5.26E-15	3.60E-11	2.25E-10	3.54E-12	3.21E-14	3.42E-17	1.81E-20	0.00E+00	0.00E+00	7.79E-10	1.72E-12
Carassius auratus (E)	4901.075	1.64E-08	3.67E-09	4.21E-08	7.04E-11	6.58E-15	1.72E-11	1.55E-10	3.20E-12	1.15E-14	9.03E-18	3.45E-21	0.00E+00	0.00E+00	5.00E-10	9.42E-13
Coilia nasus (W)	774.7502	2.08E-08	6.22E-09	4.16E-08	6.23E-11	5.26E-15	3.60E-11	2.25E-10	3.54E-12	3.21E-14	3.42E-17	1.81E-20	0.00E+00	0.00E+00	7.79E-10	1.72E-12
Coilia nasus (E)	1785.139	1.91E-08	4.28E-09	4.26E-08	6.65E-11	5.80E-15	2.11E-11	1.70E-10	3.79E-12	1.44E-14	1.15E-17	4.46E-21	0.00E+00	0.00E+00	6.03E-10	1.16E-12
Parabramis pekinensis (W)	815.7959	7.36E-09	3.87E-09	7.41E-08	2.57E-10	5.14E-14	1.62E-11	2.64E-10	1.40E-12	2.13E-14	3.40E-17	2.72E-20	0.00E+00	0.00E+00	3.53E-10	1.14E-12
Parabramis pekinensis (E)	1704.638	1.64E-08	3.67E-09	4.21E-08	7.04E-11	6.58E-15	1.72E-11	1.55E-10	3.20E-12	1.15E-14	9.03E-18	3.45E-21	0.00E+00	0.00E+00	5.00E-10	9.42E-13
Neosalanx taihuensis (W)	3384.975	1.82E-08	4.00E-09	4.44E-08	7.27E-11	6.66E-15	2.11E-11	1.84E-10	3.55E-12	1.55E-14	1.34E-17	5.64E-21	0.00E+00	0.00E+00	6.07E-10	1.26E-12
Neosalanx taihuensis (E)	2671.141	4.09E-08	4.14E-09	1.90E-08	1.36E-11	5.42E-16	4.71E-11	1.74E-10	8.41E-12	3.35E-14	2.81E-17	1.15E-20	0.00E+00	0.00E+00	1.37E-09	2.83E-12
Culter alburnus (W)	1103.26	7.36E-09	3.87E-09	7.41E-08	2.57E-10	5.14E-14	1.62E-11	2.64E-10	1.40E-12	2.13E-14	3.40E-17	2.72E-20	0.00E+00	0.00E+00	3.53E-10	1.14E-12
Culter alburnus (E)	1749.721	2.09E-08	3.92E-09	3.54E-08	4.81E-11	3.65E-15	2.29E-11	1.64E-10	4.22E-12	1.57E-14	1.26E-17	4.92E-21	0.00E+00	0.00E+00	6.50E-10	1.24E-12

Table S5 Correlation analysis between BAF and the mass molarity and proportion of Zn species.

	the mass molarity of Zn morphologies		the proportion of Zn morphologies					
	Zn^{2+}	$Zn(OH)_2$	$ZnOH^{+}$	$ZnCl^{+}$	ZnOHCl	ZnF^{+}	$ZnSO_4$	$Zn(SO_4)_2^{2-}$
BAF	-0.659**	-0.770**	0.744**	0.529*	-0.785**	0.635*	-0.686**	-0.719**

**. At level 0.01 (two-tailed), the correlation was significant.

*. At level 0.05 (two-tailed), the correlation was significant.

Table S6 BCR extraction fractions of Zn.

	Exchangeble (μg/g)	**Reducible (μg/g)**	**Oxidisable (μg/g)**	**Residual (μg/g)**	**Recovery rate**	**Total (μg/g)**
L1	91.28	118.63	22.05	50.29	1.05	269.94
L2	12.77	17.70	10.08	34.79	0.96	78.24
L3	12.56	22.14	10.74	42.31	0.83	106.06
L5	10.24	20.84	12.72	66.75	0.96	115.12
L6	11.62	11.50	12.29	57.81	0.82	113.25

Table S7 Trophic levels of the different fish.

Fish species	TL
Cyprinus carpio (HB)	3.957872
Cyprinus carpio (ZG)	3.416238
Cyprinus carpio (NF)	2.657757
Cyprinus carpio (Z)	3.25933
Cyprinus carpio (SWL)	2.93252
Carassius auratus (W)	5.483565
Carassius auratus (E)	4.582826
Coilia nasus (W)	6.166775
Coilia nasus (E)	5.095905
Parabramis pekinensis (W)	5.234156
Parabramis pekinensis (E)	3.702229
Neosalanx taihuensis (W)	5.638742
Neosalanx taihuensis (E)	4.835281
Culter alburnus (W)	5.794129
Culter alburnus (E)	5.459926

Table S8 The feeding habits, food sources, and habitat of different fish species.

Species	Feeding habits	Food Source	Habitat
Cyprinus carpio	Herbivorous(main) omnivorous	Plant foods (aquatic grasses, algae, moss, corn, sorghum, rice); Animal food (fish, shrimp, shellfish, earthworms)	The bottom water
Carassius auratus	Herbivorous(main) omnivorous	Plant food (plant debris, aquatic grasses, algae, etc.); Animal food (cladicorns, copepods, bryozoans, rotifers, freshwater shells, clams, midge larvae, shrimp, etc.)	The bottom water
Coilia nasus	Carnivorous(main) omnivorous	Fish, shrimp, squid, earthworms, insects, frogs	The surface water
Parabramis pekinensis	Herbivorous(main)	Aquatic vascular plants (bitter grass, black algae of wheel leaf, eye seed, etc); Terrestrial grasses, vegetable leaves; Plant debris in sediment and zooplankton	The bottom water
Neosalanx taihuensis	Carnivorous(main) omnivorous	Plankton, shrimp and fry	The middle and lower layers of the water
Culter alburnus	Carnivorous(main)	Fish, shrimp, aquatic insects, plankton, aquatic plants	The middle and upper layers of the water

Table S9 The body length and weight of sampling fish.

Scientific name	Body length/cm	Weight/g
Cyprinus carpio	33±9.4	395.0±176.3
Carassius auratus	18.2±1.4	173.4±39.0
Coilia nasus	34.9±0.8	128.2±15.0
Parabramis pekinensis	20.1±1.5	197.8±48.0
Neosalanx taihuensis	6.7±0.4	2.7±0.5
Culter alburnus	32±1.8	370.4±20.0

Section 1

In this study, an improved BCR extraction method was adopted extracted and analyzed the chemical fractions of trace elements in sediments, and the extraction methods were as follows (Mossop & Davidson, 2003):

Step 1-Extractable fraction: Put 1 g freeze-dried and 100-mesh sieved sediment in tube, and add 40 mL 0.11 mol/L CH_3COOH (AR, Sinopharm Chemical Reagent, China) and shake at 25℃ for 16h. The supernatant was taken after centrifugation at 6000 r/min for 15 min, filtered by 0.45μm membrane, and stored in a refrigerator at 4℃ for test.

Step 2-Redusible fraction: Add 40 mL 0.1mol /L $NH_2OH·HCl$ (AR, Sinopharm Chemical Reagent, China) to the residues of step 1, repeat the above operations, and put the filtered supernatant into the refrigerator at 4℃ for storage to be measured.

Step 3-Oxidizable fraction: Add 10 mL 8.8 mol/L H_2O_2 (AR, Sinopharm Chemical Reagent, China) into the residues of Step 2 (add it 5 to 10 times to prevent the violently reacted liquid from erupting), after intermittent shock, dissolve it in a water bath at 85℃ until the volume of the mixture is reduced to 2 to 3 mL, and then add 1 mol/L NH_4Ac (AR, Sinopharm Chemical Reagent, China) into the mixture. After repeating the above steps of shock, centrifugation and filtration, the filtered supernatant is stored in the refrigerator at 4 ° C to be measured.

Step 4-Residual fraction: The residue obtained in step 3 is freeze-dried, and digested by microwave in a mixed acid solution of HNO_3 (AR, Sinopharm Chemical Reagent, China) -$HClO_4$ (AR, Sigma-Aldrich, USA)-HCl (AR, Sigma-Aldrich, USA), and then diluted and filtered with a 0.45-μm filter membrane.

The recovery rates were calculated as follows:

$$\text{The recovery rate} = \frac{\text{F1} + \text{F2} + \text{F3} + \text{F4}}{\text{Total concentration}} \times 100\%$$

Where F1, F2, F3 are the concentration of trace elements in step 1, 2, 3, and F4 is the concentration of residuals, Total concentration is the concentrations of trace elements in sediment.

Section 2:

Take the R1 water sample for example:

```
DATABASE phreeqc.dat
SOLUTION R1 FROM NORDSTROM AND OTHERS (1979)
units ppm
pH 8.07
Density 1.023
Temp 34.9
Li 0.0001
```

Na 32.8624
K 0.0396
Mg 0.0515
Ca 0.1587
F 0.3257
Cl 10.5072
N(3) 0.1122
Br 0
N(5) 5.1604
S(6) 0
N(-3) 0.0009 as NH4
Zn 0.25 ppb N(5)/N(-3)
SOLUTION_MASTER_SPECIES
Zn Zn+2 0.0 65.409 65.409
Zn(2) Zn+2 0.0 65.409
SOLUTION_SPECIES
Zn+2 = Zn+2
log_K 0.0
gamma 6.0 0.0
SOLUTION_SPECIES
Zn+2 + Cl- = ZnCl+
log_k 0.43
delta_h 7.79 kcal
gamma 4.0 0.0
Zn+2 + 2Cl- = ZnCl2
log_k 0.45
delta_h 8.5 kcal
Zn+2 + 3Cl- = ZnCl3-
log_k 0.5
delta_h 9.56 kcal
gamma 4.0 0.0
Zn+2 + 4Cl- = ZnCl4-2
log_k 0.2
delta_h 10.96 kcal
gamma 5.0 0.0
Zn+2 + F- = ZnF+
log_k 1.15
delta_h 2.22 kcal
Zn+2 + H2O = ZnOH+ + H+
log_k -8.96
delta_h 13.4 kcal
Zn+2 + 2H2O = Zn(OH)2 + 2H+

log_k -16.9
Zn+2 + 3H2O = Zn(OH)3- + 3H+
log_k -28.4
Zn+2 + 4H2O = Zn(OH)4-2 + 4H+
log_k -41.2
Zn+2 + H2O + Cl- = ZnOHCl + H+
log_k -7.48
Zn+2 + SO4-2 = ZnSO4
log_k 2.37
delta_h 1.36 kcal
Zn+2 + 2SO4-2 = Zn(SO4)2-2
log_k 3.28
Zn+2 + Br- = ZnBr+
log_k -0.58
Zn+2 + 2Br- = ZnBr2
log_k -0.98
END

Beginning of initial solution calculations

References

Ahmed A S, Rahman M, Sultana S, Babu S O F, Sarker M S I (2019). Bioaccumulation and heavy metal concentration in tissues of some commercial fishes from the Meghna River Estuary in Bangladesh and human health implications. Marine pollution bulletin, 145: 436─447 doi: 10.1016/j.marpolbul.2019.06.035

Ai L, Ma B, Shao S, Zhang L, Zhang L (2022). Heavy metals in Chinese freshwater fish: Levels, regional distribution, sources and health risk assessment. Science of the Total Environment, 853: 158455 doi:10.1016/j.scitotenv.2022.158455

Chen L (2013). Exposure levels and health risk assessment of trace elements in food of animal origin and wild fish in Taihu Lake in Shanghai. Dissertation for the Master Degree. China: Shanghai University (in Chinese)

Condor A, Custodio M, Chanamé F, Cuadrado W, Peñaloza R (2021). Heavy Mmetals and Arsenic arsenic in Waterwater, Sediment sediment and the Muscle muscle of Oncorhynchus oncorhynchus mykiss from the Tishgo river River in the Central Andes of Peru. Journal of Ecological Engineering, 22(4): 156–166 doi:10.12911/22998993/134045

Jiang X, Wang J, Pan B, Li D, Wang Y, Liu X (2022). Assessment of heavy metal accumulation in freshwater fish of Dongting Lake, China: Effects of feeding habits, habitat preferences and body size. Journal of Environmental Sciences-(China), 112: 355–365 doi:10.1016/j.jes.2021.05.004

Maurya P K, Malik D S, Yadav K K, Kumar A, Kumar S, Kamyab H (2019). Bioaccumulation and potential sources of heavy metal contamination in fish species in River Ganga basin: Possible human health risks evaluation. Toxicology Reports, 6: 472–481 doi:10.1016/j.toxrep.2019.05.012

Mossop K F, Davidson C M (2003). Comparison of original and modified bcr sequential extraction procedures for the fractionation of copper, iron, lead, manganese and zinc in soils and sediments. Analytica Chimica Acta, 478(1): 111─118 doi: 10.1016/s0003-2670(02)01485-x

Noël L, Chekri R, Millour S, Merlo M, Leblanc J C, Guérin T (2013). Distribution and relationships of As, Cd, Pb and Hg in freshwater fish from five French fishing areas. Chemosphere, 90(6): 1900─1910 doi: 10.1016/j.chemosphere.2012.10.015

Plessl C, Gilbert B M, Sigmund M F, Theiner S, Avenant-Oldewage A, Keppler B K, Jirsa F (2019). Mercury, silver, selenium and other trace elements in three cyprinid fish species from the Vaal Dam, South Africa, including implications for fish consumers. Science of the Total Environment, 659: 1158─1167 doi: 10.1016/j.scitotenv.2018.12.442

Szara-Bąk M, Baran A, Klimkowicz-Pawlas A, Tkaczewska J, Wojtasik B (2021). Mobility, ecotoxicity, bioaccumulation and sources of trace elements in the bottom sediments of the Rożnów reservoir. Environmental Geochemistry and Health, 43(11): 4701–4718 doi:10.1007/s10653-021-00957-4

Varol M, Kaçar E, Sünbül M R, Islam A R M T (2022). Levels of metals and elements in tissues of fish species in the Kızılırmak River (Turkey) and assessment of health risks and nutritional benefits. Environmental Research, 214: 113791 doi:10.1016/j.envres.2022.113791

Yi Y, Yang Z, Zhang S (2011). Ecological risk assessment of heavy metals in sediment and human health risk assessment of heavy metals in fishes in the middle and lower reaches of the Yangtze River Basin. Environmental Pollution, 159(10): 2575─2585 doi: 10.1016/j.envpol.2011.06.011

Yin J, Liu Q, Wang L, Li J, Li S, Zhang X (2018). The distribution and risk assessment of heavy metals in water, sediments, and fish of Chaohu Lake, China. Environmental Earth Sciences, 77: 1─12 doi: 10.1007/s12665-018-7276-y