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Seasonal variations of heavy metal concentration in *Sardinella sindensis* (Day, 1878) from Balochistan coast

Quratulan Ahmed[1*], Semra Benzer[2], Naeema Elahi[3]

[1]*The Marine Reference Collection and Resources Centre, University of Karachi, Karachi, Pakistan.*

[2]*Department of Science Education, Gazi Faculty of Education, Gazi University, Teknikokullar, 06500 Ankara, Turkey.*

[3]*Department of Zoology, University of Karachi, Karachi, Pakistan.*

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ABSTRACT

Objective: To determine Fe, Cu, Zn, Pb and Cd concentrations in muscle of sind sardinella [*Sardinella sindensis* (*S. sindensis*)] from Balochistan coast, Pakistan.

Methods: *S. sindensis* were collected from Balochistan coast, Pakistan, at autumn inter monsoon, north east monsoon, spring inter monsoon and south west monsoon during October 2005-September 2006. All samples were analyzed for Fe, Cu, Zn, Pb and Cd by AAnalyst 700 flame atomic absorption spectrophotometer.

Results: Generally, *S. sindensis* caught from Balochistan coast showed the accumulation level of Fe [(16.88 ± 5.60) μg/g], Cu [(2.74 ± 1.89) μg/g], Cd [(0.29 ± 0.25) μg/g], Zn [(4.29 ± 2.31) μg/g] and Pb [(0.24 ± 0.24) μg/g] in the muscle tissues.

Conclusions: The metal concentrations in fish from Balochistan coast observed in this study were lower than the limit values. Therefore, all metal accumulations in *S. sindensis* have to be monitored continuously, especially in this region.

1. Introduction

Fishes are excellent sources of digestible proteins, vitamins, minerals and polyunsaturated fatty acids[1], but also the sources of heavy metals. Some of the metals found in the fish might be fundamental as they play a vital role in biological system of the fish as well as of human beings; some of them may, however, be toxic and cause serious damage to the human health if the present amount exceeds the permitted limits. The common heavy metals that are found in fish may include Cu, Fe, Zn, Ni, Mn, Hg, Pb, Cd, *etc*. from Pakistan waters or elsewhere[2-14]. Heavy metals have the tendency to accumulate in various organs of marine organisms, especially fish, which in turn may enter into the human metabolism through consumption, causing serious health hazards[15]. Fe, Cu, Zn and Mn are essential (physiological) metals.

The marine organisms accumulate contaminants such as metals from the environment and have been extensively used in marine pollution monitoring programmes[16,17]. These metals accumulate in fish from water, food, sediment and some suspended particulate materials[7]. In many countries, industrial wastes, geochemical structure and mining of metals create a potential source of heavy metals pollution in the aquatic environment due to their toxicity and accumulation. Under certain environmental conditions, these heavy metals might accumulate up to a toxic concentration and cause ecological damage[18].

On the other hand, industrial and agricultural activities also were reported to be the largest contributor to the accumulation of pollutants in the aquatics including seawater[19].

Balochistan is the least populated province in Pakistan. It

*Corresponding author: Quratulan Ahmed, University of Karachi, The Marine Reference Collection and Resources Centre, Karachi, Pakistan.

Tel: +92-345-2983586

Fax: 99261330

E-mail: quratulana@gmail.com

comprises nearly 70% of the total coastline, which extends from Hub River to the Iranian border. Balochistan lies between 24°55' N and 32°04' N and 61° E and 70°15' E and is the biggest province of Pakistan in term of area that more then 50% of the area is covered by high dry mountain and hills[20].

The objective of this study is to determine heavy metal (Fe, Cu, Zn, Pb and Cd) concentration in *Sardinella sindensis* (Day, 1878) (*S. sindensis*) from October 2005-September 2006.

2. Materials and methods

Samples of *S. sindensis* were collected among seasons (at autumn inter monsoon, north east monsoon, spring inter monsoon and south west monsoon) from Balochistan coast. After collection, fish samples were immediately transported to the laboratory, thawed and rinsed in distilled water to remove foreign particles. Fresh length (cm) and weight (g) were measured. Fish were tagged for identification and then frozen until time for analysis. After biometric measurements, approximately 2 g of the epaxial muscle on the dorsal surface of the fish from each sample was dissected and washed with distilled water, then dried in filter paper, weighted, packed in polyethylene bags and kept at -20 ˚C until analysis. AAnalyst 700 atomic absorption spectrophotometer was used in the present study in Centralized Science Laboratory, University of Karachi. The absorption wavelengths (λ) used for the determination of various metals are as follows: Fe: 248.30 nm; Cu: 324.70 nm; Zn: 213.90 nm, Pb: 217.00 nm and Cd: 228.80 nm. Due to the lack of a reference standard material, accuracy of the analysis and the effect of the matrices in the media were controlled with the standard addition method. All studied elements were tested with standard addition method in 3 randomly selected samples. The samples taken from the muscle tissues were dried first and cut into pieces as small as possible. About 3-20 mg portions were taken from the dried samples, placed into teflon cylindrical vessels and digested with 3 mL of H_2O_2/HNO_3 (1:2, v/v) at 250 ˚C. The organic part was discarded and the remaining part was diluted with demineralized water to 50 mL in a graduated flask[21].

All heavy metals concentrations within muscle tissues in *S. sindensis* among seasons were determined by Mann-Witney *U*-test and Kruskal-Wallis analysis of variance. The results were evaluated statistically significant at $P < 0.05$. The elements which were common in the muscle tissue of *S. sindensis* were assessed by means of Pearson's correlation coefficients. Data collection and statistical calculations were performed by SPSS version 18 software.

3. Results

Length and weight (min-max) of the fish was 15-25 cm and 33-68 g. The metal (Fe, Cu, Zn, Pb and Cd) contents in *S. sindensis* in different seasons were given in Table 1. Average metal concentrations are also given in Table 1.

In this study, the highest Fe content was 33.34 μg/g in muscle while the lowest was 7.78 μg/g in muscle. The highest Cu content was 9.78 μg/g in muscle while the lowest was 0.32 μg/g in muscle. It was found that the highest Cd content was 1.02 μg/g in muscle and the lowest was 0.01 μg/g in muscle. The highest Zn content was 12.40 μg/g in muscle and the lowest was 1.08 μg/g in muscle. Minimum and maximum values of Pb were 0.01 and 0.87 μg/g in muscle, respectively (Table 1).

Accumulation of metals in muscles was observed in the following order of Fe > Zn > Cu > Cd > Pb. Respectively, accumulation of metals in muscles at autumn inter monsoon, north east monsoon, spring inter monsoon and south west monsoon was observed to follow the order of Fe > Zn > Cu > Cd > Pb, Fe > Zn > Cu > Cd > Pb, Fe > Zn > Cu > Cd > Pb and Fe > Zn > Cu > Pb > Cd (Table 1).

Table 1
In different seasons, heavy metal concentrations in *S. sindensis* (μg/g).

Seasons		Fe	Cu	Zn	Pb	Cd
Autumn inter monsoon	Minimum	12.44	1.22	1.08	0.10	0.02
	Maximum	23.66	4.98	6.60	0.12	0.40
	Mean	16.09	2.21	4.23	0.03	0.18
	SEM	3.78	1.32	1.80	0.03	0.13
North east monsoon	Minimum	12.33	0.32	1.22	0.06	0.01
	Maximum	27.90	2.98	6.73	0.23	0.67
	Mean	16.67	1.68	3.54	0.13	0.22
	SEM	4.16	0.84	1.68	0.05	0.19
Spring inter monsoon	Minimum	8.34	1.07	2.12	0.01	0.07
	Maximum	28.98	5.56	8.08	0.44	0.60
	Mean	17.90	3.65	4.00	0.22	0.26
	SEM	6.16	1.33	2.04	0.13	0.20
South west monsoon	Minimum	7.78	1.07	2.18	0.16	0.07
	Maximum	33.44	9.78	12.40	0.87	1.02
	Mean	16.86	4.41	5.39	0.52	0.46
	SEM	7.91	2.54	3.26	0.23	0.34
All Seasons	Minimum	7.78	0.32	1.08	0.01	0.01
	Maximum	33.34	9.78	12.40	0.87	1.02
	Mean	16.88	2.74	4.29	0.24	0.29
	SEM	5.60	1.89	2.31	0.24	0.25

Accumulation of Fe in muscles in different seasons decreased in the order: spring inter monsoon > south west monsoon > north east monsoon > autumn inter monsoon. Accumulation of Cu metals in muscles was observed to follow the decreasing order of south west monsoon, spring inter monsoon, autumn inter monsoon and north east monsoon. Accumulation of Cd and Pb metals in muscles was observed to follow the decreasing order of south west monsoon, spring inter monsoon, north east monsoon and autumn inter monsoon (Table 1).

Trace metal concentrations in fish tissues in other studies and guidelines were given in Table 2. Pearson correlation coefficients between metal concentrations in the muscle tissues of *S. sindensis* were given in Table 3.

The heavy metal accumulation in muscles of *S. sindensis* was found to be less than the nationally and internationally stipulated values and posed no serious health risk (Table 4).

Table 2
Comparison of concentration in fish tissues.

Locations/Limits	Fish	Metal concentrations (μg/g)					Reference
		Fe	Cu	Zn	Pb	Cd	
Kalpakkam	*Sardinella longiceps*	75.83	3.21	23.69	0.910	-	[22]
Bay of Bengal	*Rastrelliger kanagurta*	42.00	2.20	16.00	-	-	[23]
Kapar	*Aiolopus thalassinus*	-	1.21	20.54	-	0.06	[24]
	Johnius belangeri	-	0.66	18.27	-	0.06	[24]
Mersing	*Aiolopus thalassinus*	-	1.56	30.21	-	0.03	[24]
	Johnius belangeri	-	0.95	13.12	-	0.04	[24]
Port Blair	*Sardinella gibbosa*	0.00	0.00	45.60	0.000	0.00	[25]
Kochi	*Sardinella gibbosa*	35.20	11.30	31.80	0.900	0.00	[25]
Persion Gulf	*Sardinella sindensis*	1.24	1.43	-	0.184	0.03	[26]
Kalpakkam region St 1	*Rastrelliger kanagurta*	-	-	13.76	1.850	0.87	[27]
Kalpakkam region St 2	*Rastrelliger kanagurta*	-	-	22.87	2.970	1.12	[27]
India	*Rastrelliger kanagurta*	-	2.75	24.40	0.340	3.11	[28]
India	*Rastrelliger kanagurta*	32.40	1.90	18.30	-	0.62	[12]
Keti Bunder Thatta	*Sardinella sindensis*	0.10	0.01	1.22	0.200	0.03	[11]
Balochistan	*Sardinella sindensis*	16.88	2.74	4.29	0.240	0.29	This study
International limits		100	30	50	2	1	[29]
		-	10-100	40	0.5	0.5	[30]

-: Not determined.

Table 3
Pearson correlation coefficients between metal concentrations in the muscle tissues of *S. sindensis*.

Metal	Fe	Cu	Zn	Pb	Cd
Fe	1.000				
Cu	-0.073	1.000			
Zn	0.149	0.159	1.000		
Pb	0.147	0.436**	0.049	1.000	
Cd	0.131	0.134	-0.030	0.353*	1.000

**: $P < 0.01$; *: $P < 0.05$.

Table 4
The estimated daily and weekly intakes for the economically important fish species consumed by adults in Pakistan.

Metal	PTWI	PTWI[b]	PTDI	*S. sindensis* EWI (EDI)
Fe	5600[a]	336000	48000	557.04 (79.58)
Cu	3500[a]	210000	30000	90.42 (12.92)
Zn	7000[a]	420000	60000	141.57 (20.22)
Pb	25[a]	1500	214.29	7.92 (1.13)
Cd	7[a]	420	60.00	9.57 (1.37)

PTWI: Provisional permissible tolerable weekly intake (g/week/kg body weight); [a]: PTWI stipulated by FAO/WHO[31]; [b]: PTWI for 60 kg adult person (g/week/60 kg body weight); PTDI: Permissible tolerable daily intake (g/day/60 kg body weight); EWI: Estimated weekly intake (g/week/60 kg body weight); EDI: Estimated daily intake (g/day/60 kg body weight).
Mean weekly fish consumption in Pakistan is 33 g per person[32].

4. Discussion

Accumulation of Fe in fish was reported as 0.00-75.83 mg/kg; Cu was reported as 0.00-11.30 mg/kg; Zn values were reported as 1.22-45.60 mg/kg; Pb values were reported as 0.000-2.970 mg/kg; Cd values were reported 0.03-3.11 mg/kg respectively at literature[11-22].

In this study, Fe accumulation in muscle is higher than that reported by Khoshnood *et al*[26], and Kaladharan *et al*[25], and lower than the reported data from other studies[11,12,22,23]. Cu accumulation in muscle is lower than the data reported by Biswas *et al*[22]. Cd value is lower than the reported data from some studies[12,27,28], but higher than the data reported by Bashir *et al*. and Khoshnood *et al*[24,26]. Zn values are lower than reported data from some studies by other researchers[12,22-25,27,28], while Zn values are higher than reported data from research done by Tabinda *et al*[11]. Pb values are lower than reported data from some literature[22,25,27], but higher than reported data by Khoshnood *et al.* and Rejomon *et al*[26,28].

Differences ($P > 0.05$) in Cu accumulation were observed at north east monsoon and south west monsoon. No differences ($P > 0.05$) in Pb accumulation were observed between north east monsoon and spring inter monsoon.

Respectively, there is no difference ($P > 0.05$) between the seasons in accumulation of Fe, Cd and Zn. Differences ($P < 0.05$) between Pb and Cu accumulation were observed at north east monsoon and south west monsoon. Differences ($P < 0.05$) in Pb accumulation were observed at all seasons except for north east monsoon as well as spring inter monsoon. In the present study, there is no high correlation between the metals. Pb showed a weak correlation between Cu and Cd. There are correlations between Cu and Pb ($r = 0.436$), Pb and Cd ($r = 0.353$). The other correlations between metals were not significant. There are positive correlations between Fe and Zn, Fe and Pb, Fe and Cd, Cu and Zn, Cu and Pb, Cu and Cd, Zn and Pb, Pb and Cd. Negative correlations were found between Fe and Cu, Zn and Cd.

To evaluate the health risk of heavy metals in marine fish to Pakistan people, daily intake of heavy metals was estimated on the basis of the concentrations of Fe, Cu, Zn, Pb and Cd in muscles of daily taken fish. The average daily fish consumption in Pakistan is 33 g per person[32]. The heavy metal accumulation in *S. sindensis* was found to be lower than the nationally and internationally stipulated values, thus posed no serious health risk.

The results of this study show that Fe, Cu, Cd, Zn and Pb accumulations of *S. sindensis* caught from Balochistan coast were generally lower than the international limits. Therefore, bioaccumulations in all fish have to be monitored continuously, especially in these regions. The present study shows that precautions are needed to be taken in order to obviate the metal pollution in future. Otherwise, these pollution can be hazardous for fish and human health.

Conflict of interest statement

We declare that we have no conflict of interest.

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