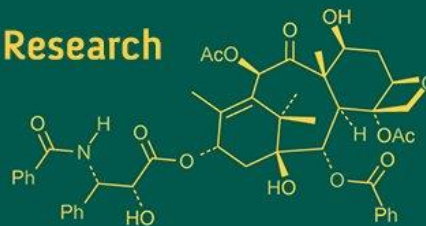


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693

ISSN Online: 2617-4707

NAAS Rating (2025): 5.29

IJABR 2025; 9(11): 35-41

www.biochemjournal.com

Received: 28-08-2025

Accepted: 30-09-2025

Narendra Kumar Maurya

Department of Aquatic
Environment Management,
College of Fisheries, Karnataka
Veterinary, Animal and
Fisheries Sciences University,
Bidar, Karnataka, India

AT Ramachandra Naik

Department of Aquatic
Environment Management,
College of Fisheries, Karnataka
Veterinary, Animal and
Fisheries Sciences University,
Bidar, Karnataka, India

MT Lakshmipathi

Department of Aquatic
Environment Management,
College of Fisheries, Karnataka
Veterinary, Animal and
Fisheries Sciences University,
Bidar, Karnataka, India

Assessment of heavy metal contamination in oil sardine (*Sardinella longiceps*) from the Mangalore coast and its implications for human health

Narendra Kumar Maurya, AT Ramachandra Naik and MT Lakshmipathi

DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i11a.6170>

Abstract

Pollutant emissions into ecosystems have grown because of industrial development. Heavy metals are among the most prevalent contaminants. This study examines the potential of metal contamination on human health by eating oil sardine fish off the coast of Mangaluru. The purpose of this study was to measure the levels of Iron, Nickel, Copper, Zinc, Lead, Cadmium, Mercury and Arsenic in the kidney, liver, muscle, and gill tissues of *Sardinella longiceps* from the Mangaluru shore. A flame atomic absorption spectrophotometer was used to analyses each sample, and the findings were reported as $\mu\text{g g}^{-1}$ dry weight. With a few exceptions, the liver has substantially greater metal concentrations than other tissues. $\text{Fe} > \text{Zn} > \text{Cu} > \text{Ni} > \text{As} > \text{Pb} > \text{Cd} > \text{Hg}$ was the order of metal accumulation concentrations in oil sardine tissues. This species' estimated daily intake (EDI) of heavy metals was less than its tolerated daily intake (TDI). Additionally, the average target hazard quotient (THQ) for the metals under study was less than 1, indicating that eating these fish may be safe for human health along the Mangaluru coast.

Keywords: Estimated daily intake (EDI), heavy metals, human health, oil sardine, pollution, and target hazard quotient (THQ)

Introduction

Sardines, often called pilchards, are tiny, greasy fish that live in streams all over the world, including the Mediterranean Sea, the Atlantic, and the Pacific. Larger, predatory fish and endangered species like seabirds depend on them as a food supply. Sardines, notably canned sardines, are a popular seafood option and are frequently used in salads, pasta, and pizza because of their low cost and high nutritional content. Sardines are popularly referred to as "Bhutai" in the native language of Tulu or "Tarli" in Mangaluru. Indian oil sardines, which make up a major portion of the region's marine harvest, are among the most well-liked and significant seafood. The protein, vitamins, and minerals found in Indian oil sardines are abundant. One 3.75-ounce (oz) can of sardines supplies 343%, 88%, 27%, and 15% of your daily requirements for B₁₂, selenium, calcium, and iron, as well as 22.6 grams (g) of protein. It can be difficult for many groups, such as pregnant women and elderly individuals, to maintain adequate amounts of essential nutrients. Omega-3 fatty acids, EPA and DHA, are abundant in sardines and have strong anti-inflammatory and health-promoting effects. Fish should thus be included in a weekly diet as it is essential for human health.

Heavy metals are known to be released into aquatic habitats, either on purpose or by accident. Anthropogenic activities including agriculture and industry are the primary sources of heavy metal pollutants in the aquatic environment (Fallah *et al.* 2011) [10]. Marine environmental degradation and detrimental impacts on the health of marine species have resulted from human usage of heavy metals in industry and other activities (Sadeghi *et al.*, 2020) [27]. Since the fish are situated at the top of the food chain, contaminants could accumulate in fish tissues and transferred to humans (Yilmaz *et al.* 2010) [39]. Exposure quantification has gained importance in recent years, as exceeding acceptable limits of pollutants set by various regulatory authorities may pose health risks to humans.

To assess the non-carcinogenic risk of heavy metal exposure to human health from eating fish, the USEPA (2000) [35] advocated the use of target hazard quotient (THQ) and total THQ

Corresponding Author:

Narendra Kumar Maurya

Department of Aquatic
Environment Management,
College of Fisheries, Karnataka
Veterinary, Animal and
Fisheries Sciences University,
Bidar, Karnataka, India

(TTHQ). To the best of our knowledge, not many research has been conducted to ascertain the bioaccumulation of heavy metals in Arabian Sea species belonging to the Clupeidae family. Additionally, no prior research has evaluated the risks of eating Indian oil sardines from the Mangaluru coast. In light of the aforementioned information, the study's objectives were to: (1) ascertain the levels of various heavy metals in the gill, liver, muscle, and kidney tissues of *Sardinella longiceps* from the Mangaluru coast; and (ii) evaluate the possible health risks to humans from consuming *S. longiceps* by comparing its EDI (estimated daily intake) of heavy metals with TDI (tolerable daily intake), THQ (target hazard quotient), and TTHQ (total target hazard quotient).

Materials and Methods

For this investigation, 40 *Sardinella longiceps* fish, a member of the Clupeidae family, were chosen in each session. This species was selected due to its significant commercial importance and extensive utilization in India. In pre-monsoon, monsoon, and post-monsoon, 2024, fish samples were taken at the Mangaluru Wharf, which is located at 12° 51' 14" N and 74° 49' 59" E. The samples were promptly taken to the lab and stored in an ice-filled cool box. Distilled water was used to wash the samples in the lab. Prior to chemical examination, the tissues of the gills, liver, kidney, and muscle were gathered, placed in sterile disposable polyethylene bags, and frozen at -20 °C (Sadeghi *et al.*, 2020) [127]. Different tissue samples from *S. longiceps* were subjected to various laboratory works following standard methods (APHA 2005) [2]. The concentration of HMs (Iron, Nickel, Copper, Zinc, Lead, Cadmium, Mercury, and Arsenic) in different tissue was determined by Atomic Absorption Spectrometer (AAS); Thermo Scientific iCE 3300 series Atomic Absorption Spectrophotometer (AAS) by using standard diluted sample solution.

Health risk assessment for fish consumption

Estimated daily intake (EDI)

The following formula, which was published by Bortey-Sam *et al.* (2015) [3], was used to calculate the estimated daily intake (EDI) of heavy metals (Iron, Nickel, Copper, Zinc, Lead, Cadmium, Mercury, and Arsenic):

$$EDI = \frac{MC \times FDC}{BW} \quad (1)$$

where MC is the average dose of heavy metal ($\mu\text{g/g}$) in fish muscle tissue, FDC is the average daily intake of fish muscle food (g/person/day), which is 25.2 g/person/day in Iran (IFO, 2015), and BW is body weight (typical adult weight of 70 kg). It was stated as $\mu\text{g/kg bw/day}$ for EDI.

Target hazard quotients

To determine the danger of heavy metal pollution to human health, target hazard quotients (THQ) were employed. Yi *et al.* (2017) [38] claim that when THQ is less than 1, it means that there are no long-term negative impacts on human health. Additionally, THQ surpassed, which may have a negative impact on customers' health. The following formula was used to determine THQ (USEPA, 2000) [35]:

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times BW \times ATn} \times 10^{-3} \quad (2)$$

where ED is the exposure duration (years) and EF is the exposure frequency (days per year); The food intake rate (g/person/day) is denoted as FIR. RFD is the oral reference dose ($\mu\text{g g}^{-1}/\text{day}$); C is the metal content in fish ($\mu\text{g/g}$). ATn is the average exposure time for noncarcinogen effects (days per year $\times$ ED), and BW is body weight (kg). Table 1 displays all the parameters and values utilized in the THQ estimate.

Using the methodology of Li *et al.* (2013) [16], total THQ (TTHQ) was computed as the sum of the individual THQ for each metal in each species:

$$TTHQ = THQ (\text{toxicant 1}) + THQ (\text{toxicant 2}) + \dots \dots \dots THQ (\text{toxicant n}) \quad (3)$$

A TTHQ number greater than 1 often denotes the possibility of harmful impacts on human health and the necessity of doing more research or even corrective action.

Results and Discussion

Heavy metal accumulation

Table 2 shows the levels of heavy metals (Fe, Zn, Ni, Pb, Cd, Cu, Hg, and As) in the liver, gills, kidney, and muscles of the studied fish species during the pre-monsoon, monsoon, and post-monsoon seasons of 2024. All tissues at all the seasons, general pattern of heavy metal accumulation was as follows: Fe > Zn > Cu > Ni > As > Pb > Cd > Hg, reflecting both environmental availability and physiological affinity of these elements. Such a trend has been reported in several coastal biomonitoring studies (Olojo *et al.*, 2012; Sujitha *et al.*, 2019) [23, 32], where essential trace elements like Fe, Zn, and Cu typically dominate due to their biological roles in metabolism and enzyme function.

The results of the ANOVA showed that metal accumulation differed significantly across metals, seasons, and tissues. The effects of season ($p = 0.024$), heavy metals ($p < 0.001$), and organ ($p < 0.001$) were all statistically significant. Furthermore, while the three-way interaction (Season $\times$ Heavy Metals $\times$ Organ) was not significant ($p = 0.596$), indicating consistent seasonal trends across organs, significant interactions between Season $\times$ Heavy Metals ($p = 0.025$) and Heavy Metals $\times$ Organ ($p < 0.001$) authenticated that both temporal variability and organ-specific uptake impact bioaccumulation patterns (Table 3).

Iron (Fe) had the highest amounts among the metals in every tissue, with the liver having the highest value ($59.24 \pm 1.12 \mu\text{g g}^{-1}$) during the monsoon season (Fig. 1A) and the muscle having the lowest value ($5.84 \pm 0.77 \mu\text{g g}^{-1}$) during the pre-monsoon could be attributed to enhanced terrestrial runoff, resuspension of sediments, and influx of industrial and domestic effluents from adjoining river systems, which increase dissolved and particulate iron availability in the coastal waters (Eyre, 1994; Chan *et al.*, 2025) [8, 5]. Similar monsoon-driven enrichment has been reported along the west coast of India (Velusamy *et al.*, 2014) [14], Rejomon *et al.* (2010) [26] observed Fe concentrations varying from 438.30 to 649.60 $\mu\text{g/g}$ in fishes from Kochi, while in Mangalore, Fe content ranged from 333.30 to 541.60 $\mu\text{g/g}$, which was more than the current findings.

Zinc (Zn) was also found in higher concentrations in all tissues, with the liver having the greatest concentration ($80.62 \pm 6.48 \mu\text{g g}^{-1}$) during the monsoon and the kidney having the lowest ($7.98 \pm 1.70 \mu\text{g g}^{-1}$) during the post-monsoon (Fig. 1B), are also indicative of bioavailability

from anthropogenic inputs such as fertilizers, paint residues, and antifouling coatings (Turner *et al.*, 2008; Shah, 2021)^[34, 30]. Although Zn is an essential element, elevated levels can reflect contamination stress, particularly when values exceed typical physiological ranges (Muszyńska and Labudda, 2019)^[21]. Iron (Fe) and zinc (Zn) were found in significantly higher concentrations than other metals, particularly in the liver, indicating active metal sequestration and detoxification functions of this organ (Mehta and Flora, 2001; Jamakala *et al.*, 2014)^[20, 14]. The range of nickel (Ni) during monsoon in muscles values from $0.08 \pm 0.10 \mu\text{g g}^{-1}$ to $1.70 \pm 1.49 \mu\text{g g}^{-1}$ in liver Fig. 1C. Similar to recent study, Hossain *et al.* (2022)^[12] measured Ni in four marine fish and shrimp species (*Labeo bata*, *Sillaginopsis panijus*, *Platycephalus fuscus*, and *Penaeus monodon*) in Northern Bay of Bengal. They reported that mean Ni concentration ($0.4 \pm 0.3 \mu\text{g/g}$) and showed in the descending order of accumulation; *P. monodon* > *S. panijus* > *P. fuscus* > *L. bata*, which implies that bottom dwellers and omnivores had higher levels of metals. The levels of lead (Pb) in liver during monsoon were observed to be quite low, ranging from $0.159 \pm 0.018 \mu\text{g g}^{-1}$ to $0.027 \pm 0.003 \mu\text{g g}^{-1}$ in muscle during post monsoon Fig. 1D. Oyibo *et al.* (2018) reported Pb concentration in different finfish species from Forcados Terminal, Delta State, Nigeria, among that highest recorded in 5.54 ± 0.02 (*M. cephalus*), 0.68 ± 0.01 (Tilapia). Copper (Cu) and nickel (Ni) exhibited a moderate accumulation, largely concentrated in metabolically active organs like liver and kidney (Ali *et al.*, 2023). Their monsoonal peaks of metal accumulation suggest enhanced leaching from agricultural runoff and industrial discharges. These elements are known to associate with organic matter and suspended particulates, which become mobilized during heavy rainfall and turbulence (Singh and Yadav, 2025)^[31]. Cadmium (Cd) concentrations were likewise low in all tissues, with muscle having a minimum of $0.001 \pm 0.003 \mu\text{g g}^{-1}$ during the post-monsoon and the liver having a high of $0.72 \pm 0.51 \mu\text{g g}^{-1}$ during the monsoon (Fig. 1E). Congruent to the present study, Salam *et al.* (2019) reported that highest concentrations of Cd in liver of *E. affinis* (1.89 ± 0.78) followed by *L. daura* (0.649 ± 0.9). In general, the largest concentrations of Cd were found in the liver, followed by the gill and flesh. While relatively low levels in muscle reflect effective detoxification or storage mechanisms in non-edible organs and restricted translocation to consumable tissues, the prevalence of Cd in the liver and gills suggests both food and aquatic exposure pathways. However, their presence even at trace levels warrants attention, as these metals having no biological function and can pose health risks through trophic transfer. The liver consistently showed the highest concentrations of Pb and Cd, reflecting its detoxifying role through metallothionein limited risk for human consumption when compared to non-edible organs (Liu *et al.*, 2022; Qu and Zheng, 2024)^[17, 24]. Between $0.17 \pm 0.14 \mu\text{g g}^{-1}$ in muscle during monsoon to $2.45 \pm 1.20 \mu\text{g g}^{-1}$ in liver, copper (Cu) showed a moderate buildup. At $0.005 \pm 0.001 \mu\text{g g}^{-1}$ (muscle, pre-monsoon) to $0.133 \pm 0.078 \mu\text{g g}^{-1}$ (liver, monsoon) Fig. 1F, mercury (Hg) exhibited the least amount of accumulation of any element (Fig. 1G). Arsenic (As) levels varied from $0.27 \pm 0.09 \mu\text{g g}^{-1}$ in muscle during post monsoon to $1.81 \pm 0.37 \mu\text{g g}^{-1}$ in monsoonal liver Fig. 1H. Among non-essential and toxic metals, lead (Pb), cadmium (Cd), mercury (Hg), and arsenic

(As) occurred in comparatively lower concentrations. The substantial organ-and metal-specific variations shown by ANOVA are further supported by their accumulation patterns. This is in line with the central role of liver in detoxification, biotransformation, and metal sequestration through metallothionein binding, which facilitates higher retention of Pb relative to other tissues (Thirumoorthy *et al.*, 2007; Marek and Marinescu, 2023)^[33, 18]. The very low Hg levels across tissues (0.005 – $0.133 \mu\text{g g}^{-1}$) may indicate limited methylation activity in the study area or low exposure from dietary sources (Hanna *et al.*, 2012; Martin and Fry, 2018)^[11, 19]. The monsoon season was often associated with greater metal concentrations, especially in the liver, which was followed by the kidney, gills, and muscles (Olojo *et al.*, 2012; Sujitha *et al.*, 2019)^[23, 32]. Increased freshwater influx, sediment resuspension, and erosion of contaminated catchments likely elevate metal loads in the water column, enhancing bioaccumulation in aquatic organisms (Burton and Johnston, 2010)^[4].

Health risk assessment

The quantity of pollutants consumed each day can be calculated using a method called Estimated Daily Intake (EDI) (Zaghloul *et al.*, 2022)^[40], which was calculated for Fe, Ni, Zn, Pb, Cd, Cu, Hg, and As during the pre-monsoon, monsoon, and post-monsoon seasons and reported for the fish under investigation in Table 4. Among all metals, Fe and Zn showed significantly higher EDI values across the three seasons, while Cd and Hg recorded the lower. During the monsoon season, Fe ($3.6176 \mu\text{g/day}$) and Zn ($4.8366 \mu\text{g/day}$) exhibited their peak EDI levels, whereas Cd ($0.0245 \mu\text{g/day}$) and Hg ($0.0064 \mu\text{g/day}$) remained minimal. The estimated intake of heavy metals from eating of fish muscles from the examined species was determined to be within the range of known TDIs norms (provisional tolerable daily intake "PTDI"), and hence deemed safe for consumers. When the EDIs of heavy metals detected in the fish species tested in this study were compared to the PTDI, it was discovered that the EDIs of all studied metals were lower than the PTDI limits recommended by international agencies such as WHO (1989)^[41], JECFA (2009)^[15], and Zaghloul *et al.* (2022)^[40] through consumption Mangaluru person per day. Tolerable intake is a term that is often used to describe acceptable consumption levels. This suggests that the consumption of the studied species from the Mangaluru coast poses no immediate health risk to consumers in terms of heavy-metal exposure.

Similarly to present study, de Souza-Araujo *et al.* (2022)^[6] reported EDI values of HMs and TEs in different fishes and shellfishes as As (0.19 to 11.19), Pb (0 to 0.03), Hg (0.01 to 0.42) and Cd (0 to 0.006) in marine fish from the Amazon. In another study, Noman *et al.* (2022) demonstrated that the EDI of metals through the fish muscles followed the order Zn > Cu > As > Cr > Cd > Pb > Hg. Likewise, Dokmeci *et al.* (2019)^[7] observed the EDI values of each metal in the studied bottom fish muscles were less than the RfD proposed by the USEPA (2011)^[36] in the Marmara Sea, Tekirdag, Turkey.

According to Wang *et al.* (2005)^[37] and Zaghloul *et al.* (2022)^[40], a THQ value less than one means that there are no lifetime negative effects on human health; a value greater than one means that there is a possibility of a non-carcinogenic public health hazard from heavy metal exposure, with the likelihood of such a hazard increasing

with the value, or indicates a likely adverse health effect. For the typical consumers in this investigation, the THQ values of each metal in all fish tissues were less than 1.0 (Table 5). Therefore, consuming *S. longiceps* from the coastal water of Mangaluru poses no health risks to the populace. The results of this investigation were consistent with the findings of Ezemonye *et al.* (2019) [9], who found that eating Red Sea fish did not pose any concerns because their THQ and EDI values were less than 1 (<1). Yi *et al.*

(2017) [38] and Zaghloul *et al.* (2022) [40] also showed similar results. As recommended by the USEPA (2011) [36], THQ<1 denotes no danger to human health. Our results aligned with those of Zaghloul *et al.* (2022) [40], who also discovered that TTHQ values were less than 1. Rahman *et al.* (2026) [25] reported that THQ values remained<1, suggesting no significant non-carcinogenic risks for seven commercially important fishes from the Bay of Bengal from the Bay of Bengal.

Table 1: Shows the target hazard quotients formula's parameters and values summarized statistically

Factor	Parameter Description	Unit	Value	Reference
EF	Exposure Frequency	Days/year	365	USEPA (2000) [35]
ED	Exposure Duration	Years	70	
FIR	Food Ingestion Rate	g/person/day	25.2	
C	Metal Concentration in Food	µg/g		
RfD	Oral Reference Dose	µg/g/day		
BW	Average Body Weight of Individual	kg	70	
ATn	Averaged Exposure Time for Non-Carcinogenic Assessment	Days (ED × 365)	365 × 70	

Table 2: Seasonal Variation in Heavy metals Accumulation (µg/g dry wt.) in Different Organs of *Sardinella longiceps* along the Mangaluru Coast

FT	HMs	PRM	MON	POM
K	Fe	8.985±1.277	11.173±0.165	8.888±1.396
L		45.866±7.509	59.241±1.121	34.472±10.391
G		34.344±13.186	39.837±2.391	30.916±14.816
M		5.837±0.770	10.049±0.876	7.153±2.253
K	Zn	9.545±5.065	15.643±3.568	7.979±1.702
L		53.437±27.293	80.615±6.477	23.976±5.535
G		44.114±9.123	39.351±11.220	27.209±6.088
M		8.529±5.094	13.435±6.115	10.370±6.945
K	Ni	0.216±0.197	0.170±0.052	0.308±0.093
L		1.103±0.448	1.698±1.487	1.277±0.470
G		0.981±0.614	1.318±0.296	1.087±0.305
M		0.112±0.131	0.080±0.098	0.215±0.143
K	Pb	0.067±0.008	0.076±0.016	0.056±0.007
L		0.116±0.003	0.159±0.018	0.122±0.005
G		0.094±0.003	0.110±0.012	0.119±0.017
M		0.035±0.003	0.049±0.014	0.027±0.003
K	Cd	0.055±0.048	0.130±0.114	0.004±0.008
L		0.690±0.489	0.723±0.512	0.401±0.356
G		0.675±0.380	0.573±0.423	0.088±0.092
M		0.003±0.008	0.068±0.016	0.001±0.003
K	Cu	0.344±0.069	0.765±0.514	0.490±0.111
L		1.281±0.504	2.449±1.203	1.586±0.126
G		2.316±1.571	0.710±0.126	1.280±0.527
M		0.393±0.225	0.174±0.136	0.323±0.205
K	Hg	0.022±0.010	0.037±0.009	0.015±0.006
L		0.099±0.043	0.133±0.078	0.065±0.017
G		0.031±0.008	0.071±0.045	0.038±0.019
M		0.005±0.001	0.018±0.014	0.006±0.004
K	As	0.764±0.312	0.251±0.064	0.264±0.098
L		1.720±0.266	1.808±0.367	1.277±0.195
G		1.560±0.707	1.447±0.602	1.258±0.112
M		0.749±0.472	0.374±0.156	0.279±0.090

Note:-K: Kidney; L: Liver; G: Gills; M: Muscles; HMs: Heavy Metals; FT: Fish Tissues; PRM: Pre-Monsoon; MON: Monsoon; POM: Post-Monsoon

Table 3: Analysis of Variance for the Interaction Effects of Season, Heavy Metal Type, and Fish Organ on Metal Concentrations

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	66400.762 ^a	95	698.955	17.740	.000
Intercept	15614.376	1	15614.376	396.314	.000
Season	299.810	2	149.905	3.805	.024
Heavy Metals	40423.862	7	5774.837	146.573	.000
Organ	6813.679	3	2271.226	57.647	.000
Season * Heavy Metals	1062.957	14	75.926	1.927	.025
Season * Organ	364.407	6	60.734	1.542	.166
Heavy Metals * Organ	17728.792	21	844.228	21.428	.000
Season * Heavy Metals * Organ	1540.393	42	36.676	.931	.596
Error	8825.385	224	39.399		
Total	90605.884	320			
Corrected Total	75226.147	319			

Note: Significant main effects were observed for Season, Heavy Metals, and Organ, with significant interaction effects between Season × Organ and Heavy Metals × Organ ($p < 0.05$ or $p < 0.001$ as applicable). Non-significant interactions are indicated ($p > 0.05$)

Table 4: Seasonal Variation in Estimated Daily Intake (EDI) of Fe, Ni, Cu, Zn, Pb, Cd, Hg, and As from *Sardinella longiceps* (µg/kg Body Weight/Day)

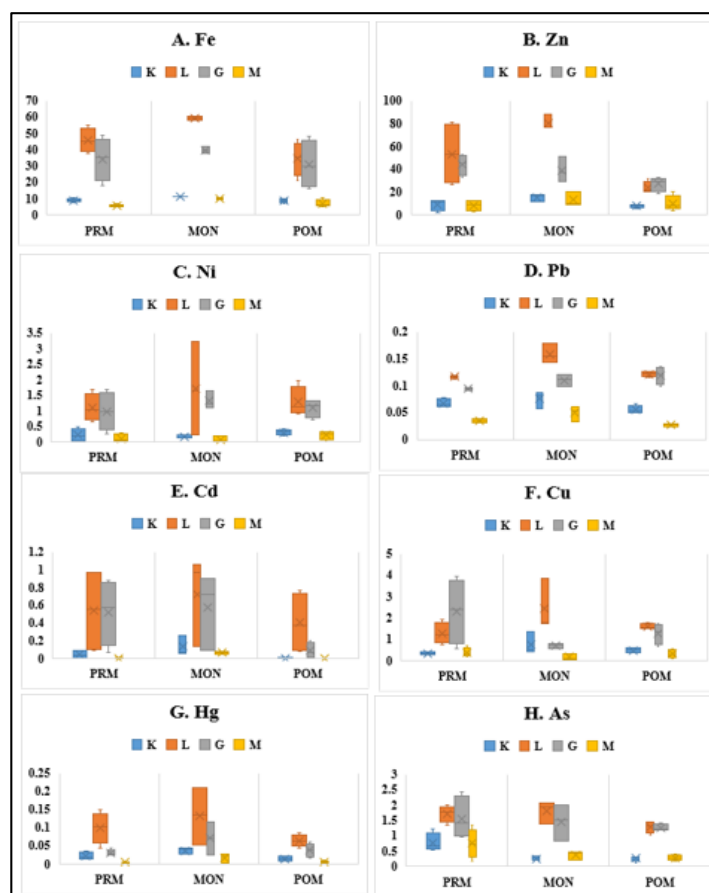
	Fe	Ni	Zn	Pb	Cd	Cu	Hg	As
PRM	2.1012	0.0402	3.0705	0.0125	0.0010	0.1415	0.0016	0.2697
MON	3.6176	0.0287	4.8366	0.0178	0.0245	0.0625	0.0064	0.1348
POM	2.5750	0.0775	3.7333	0.0096	0.0005	0.1162	0.0022	0.1005
TDI µg/day	800 Zaghoul et al., 2022 [40]	300 Zaghoul et al., 2022 [40]	8000-11000 Zaghoul et al., 2022 [40]	105 WHO (1989) [41]	58.3 WHO (1989) [41]	700 Zaghoul et al., 2022 [40]	30 JECFA, 2009 [15]	130 JECFA, 2009 [15]

Note:-PRM: Pre-Monsoon; MON: Monsoon; POM: Post-Monsoon; TDI: Tolerable Daily Intake

Table 5: Seasonal Variation in THQ and TTHQ of Fe, Ni, Cu, Zn, Pb, Cd, Hg, and As from *Sardinella longiceps*

	Fe	Ni	Zn	Pb	Cd	Cu	Hg	As	TTHQ
PRM	0.0232	0.0155	0.0790	0.0019	0.0074	0.0273	0.0001	0.0208	0.1752
MON	0.0399	0.0111	0.1244	0.0027	0.1889	0.0121	0.0005	0.0104	0.3899
POM	0.0284	0.0299	0.0960	0.0015	0.0035	0.0224	0.0002	0.0078	0.1896

Note: PRM: Pre-Monsoon; MON: Monsoon; POM: Post-Monsoon; THQ: Target hazard quotients; TTHQ: Total target hazard quotients

**Fig 1:** Boxplot of Seasonal Variation in A (Fe), B (Zn), C (Ni), D (Pb), E (Cd), F (Cu), G (Hg), and H (As) accumulation in Organs of *S. longiceps* from the Mangaluru Coast

Conclusion

The findings offer valuable information on the following topics: pollution of the marine environment; the abundance of heavy metals (HMs) in fish tested throughout the Mangaluru coast; and variations in the concentration of HMs analysed in connection to the various tissues of fish studied, sampling seasons, and other factors. Furthermore, the study's findings offer crucial information on the health risks to people posed by HM exposure from eating the fish under investigation from the Mangaluru shore. We may infer that *S. longiceps* collected in the coastal region of Mangaluru may be safe for consumers' health. Because the THQ and TTHQ values were less than 1.0, there is no non-carcinogenic health risk to the people who consume Mangaluru's coastal region. To ensure that the levels of heavy metals in seafood in this area do not beyond the permitted limits for human consumption, stringent control mechanisms should be put in place. Hence, by the findings we can blindly conclude that the studied fish can be eaten and enjoyed with no further health consequences in the coast of Mangaluru.

Acknowledgments

The authors gratefully applaud the Department of Aquatic Environment Management, College of Fisheries, Mangalore, for their assistance and encouragement during this work. The authors are also appreciative to the technical personnel, field helpers, and local fisherman for their essential aid during sample collection and fieldwork. The local community's support along the Mangalore coast is much appreciated. This study received no grants from public, commercial, or non-profit funding entities. The authors declare that there is no conflict of interest related to this research work.

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