Indian J. Anim. Res., 50 (5) 2016 : 759-763
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijaronline.in

Distribution of heavy metals in different tissues of Indian mackerel from Karachi fish harbour, Karachi, Pakistan

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Received: 18-05-2015 Accepted: 13-05-2016 DOI:10.18805/ijar.11423

ABSTRACT

In this study, Nickel (Ni), Lead (Pb), Cadmium (Cd) and Chromium (Cr) concentrations were determined in muscle, liver, kidney, gills and gonads of Indian mackerel (*Rastrelliger kanagurta*) collected from Karachi fish Harbour, Karachi coast, Pakistan, during August 2006 and December 2011. Generally, the fish showed the highest level of Ni (2.26±0.89 µg g^{-1}), Pb (1.45±0.40 µg g^{-1}), Cd (2.07±0.75 µg g^{-1}) and Cr (1.52±0.69 µg g^{-1}) in the liver. The studied metals were the most abundant in the liver than the other organs of the fish. The amount of metal accumulation in fish tissues was evaluated in terms of human health. It was seen that bioaccumulations in muscle tissues of the fish caught from Karachi coast of Pakistan did not exceed the limit values.

Key words: Accumulation, Heavy metals, Indian mackerel.

INTRODUCTION

Heavy metals form the most significant source of inorganic pollutants in the water. Heavy metals in aquatic environments increase as a result of industrial, agricultural (fertilizers and pesticides) and urban waste, apart from natural sources. They are absorbed by the aquatic ecosystem organisms and collected in their tissues and then transferred to humans through food chain (Kumar *et al.*, 2010). The ingestion of food is known as an important way of exposure to heavy metals (Sary and Mohammadi, 2012).

Metals in natural waters are found in particulate or dissolved form. Dissolved species contain labile and non-labile fractions. The most deadly material for the fish is labile metal compounds. They consist of diverse ionic forms of different availability to fish. It is reported that environmental conditions determine the amount of metals in labile fraction and the proportion of diversified metal ions (Jezierska and Witeska, 2006).

It is reported that there are negative effects in physiological functions of the fish living in the waters polluted by the metals. It is also stated that the fish which are exposed to metal pollution have weakened immune system, and so the risk of catching contagious diseases and death has increased. It is necessary to search about the effects of metal pollution on organisms (fish, crustaceans, algae) which are consumed as a source of protein and which form a link in the chain of biological life cycle. The amount of pollutant materials in these organisms should be calculated and necessary measures should be taken on time according to the obtained results (Larsson and Haux, 1985).

Karachi is the biggest city of Pakistan and located within the coordinates of 23º19 N and 24º07' N latitudes and 67º08' E and 68º54' E longitudes. The main sources of pollution in eastern part of Karachi are leather, paints, textile, pharmaceuticals, iron, steel, electrical appliances, refinery, oil, and electroplating industries and sewage water. Karachi is a big city, there are more than 65 categories of industrial plants in the established industrial estates including, textile industries, tanneries, pharmaceuticals, plastic and rubber industries, steel foundries, metallurgical industries, electroplating and metal coating industries, glass, ceramics and tiles industries, cement industry, soap and detergents, fish processing industries, chemical industries, power plants, fertilizers and pesticides edible oils, automobile cable and conductor manufacturing etc. (Shahid, 2010).

The Karachi coastline has a growing pollution , which results from the increasing shipping industry through the Karachi port. The pollution is critically contaminating the mangrove, forests and marine life and a large amount of industrial waste is caused by the industries production (World Bank, 1991). With a population above 12 million, Karachi is one of the largest industrial cities of the country and its coastal areas are in the risk of contamination of diverse pollutants (Saifullah *et al.*, 2002).

The purpose of this study is to determine the amount of heavy metal Ni, Pb, Cd and Cr concentration in muscles,

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liver, kidney, gills, and gonads in Indian mackerel fish from Karachi fish harbour, Karachi coast. With the obtained results, it is aimed to figure out whether the heavy metal amount found in the fish pose a thread to human health or not.

MATERIALS AND METHODS

Sample of fishes were collected seasonally (autumn, winter, spring, summer) from Karachi coast, Fish Harbour West Wharf Karachi. This study was carried out on 434 *Rastrelliger kanagurta* (Cuvier, 1816) between 2006 and 2011. After biometric measurements, approximately 2 g of the muscle on the dorsal surface, liver, kidney, gill and gonad of the fish from each sample were dissected and washed with distilled water. Then the samples were dried in filter paper, weighed, packed in polyethylene bags and kept at -20°C, until the analysis. AAnalyst 700 Atomic Absorption spectrophotometer was used in Centralized Science Laboratory of University of Karachi. The absorption wavelengths (l) used for the determination of various metals are as follows: Ni: 232.00 nm; Pb: 217.00 nm; Cd: 228.80 nm; Cr: 357.90 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 for 3 randomly selected samples. The samples of tissues were dried first and cut into pieces as small as possible. 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 (Bernhard, 1976).

All heavy concentrations in different tissues of *R. kanagurta*, were determined seasonally by the analyses of variance (ANOVA) with the Tukey's HDS post-hoc comparison. The results were evaluated on the basic of homogenous groups at a given significance level ($p<0.05$). Statistical calculations were performed by SPSS Ver.18 software.

RESULTS AND DISCUSSION

Length and weight (min-max) of the fish was 21.50 – 27.20 cm and 98.00 – 176.00 g. Season and year (2006-2011) wise metal (Ni, Pb, Cr and Cd) contents of *R. kanagurta* are given in Tables 1 and 2, respectively. Average Ni, Pb, Cd and Cr concentrations are given in Table 3.

The maximum accumulation in all tissues was found in the summer season, while the least was found in the seasons of autumn and winter. Pb, Cd and Cr concentrations in the fish tissue (liver) of summer season was higher than other seasons, Ni concentration in the fish tissue (kidney) of summer season was higher than other seasons (Table 2).

The accumulation of Ni was the highest in liver, kidney gills and gonad, while the accumulation of Cd was the highest in liver. It is found that the accumulation of Cr was the lowest in the liver, kidney and gill. The highest of all the elements accumulated in the liver, and the least in the muscles. The highest metal accumulations were found in the years of 2009-2011.

Pb and Cd accumulation of muscle is found higher than the studies of Despande *et al.*, (2009) and Khoshnood *et al.*, (2012). Pb accumulation of muscle values are higher than of the literature values (Biswas *et al.*, 2012). Cd and Pb values are lower than the reported data from literature (Mukherjee and Bhupander, 2011; Victor *et al.*, 2012; Rejomen *et al.*, 2010; Saravanumurugan *et al.*, 2013), while Cd values of this study are higher than Bhupander *et al.* (2012). Ni values are lower than the reported data from literature (Khoshnood *et al.*, 2012; Rejomen *et al.*, 2010), while Cr values are lower (Biswas *et al.*, 2012) (Table 4).

Respectively, no difference in the accumulation of Ni, Pb, Cd and Cr was observed between the tissues of muscle - gill, kidney –gonad; muscle - kidney, muscle - gill; kidney - gill; muscle - kidney; muscle - kidney; kidney – gill. In addition, there is no difference in the accumulation of Ni, Pb, Cd and Cr between the seasons of autumn - winter; autumn - winter, spring – summer; autumn – winter, autumn – spring, winter – spring; autumn – winter; spring – summer. There is also no difference in the accumulation of Ni, Pb, Cd and Cr - between the years in the order of: 2006-2007, 2007-2008; 2009-2010, 2010-2011; 2007-2008, 2008-2009; 2008-2009, 2009-2010.

To evaluate the health risk for the people in Pakistan through the consumption of marine fish, daily intake of heavy metals was estimated on the basis of the concentrations of Ni, Pb, Cd and Cr in the muscles of daily fish consumption. The average daily fish consumption in Pakistan is 33 g per person (Chughtai and Mahmood, 2012). The heavy metal accumulation in muscles of *R. kanagurta* was found to be below the nationally and internationally stimulated values and it was seen that this value did not pose a serious health risk (Table 5).

Rauf *et al.*, (2009) stated that fish liver exhibited the highest tendency to accumulate both Cd and Cr. In this study, the highest concentrations of heavy metals in *R. kanagurta* were found the most in liver and the lowest in muscle. Pb and Cd accumulation is lower than international limits in the muscle, while the accumulation of this metal is higher than international limits in the liver (FAO, 1983; WHO, 1989).

The results of this study show that Ni, Pb, Cd and Cr accumulations of *R. kanagurta* caught from Karachi coasts were generally below the international limits. Therefore, Ni, Pb, Cd and Cr bioaccumulations in *R. kanagurta* 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 pollutions can be hazardous for fish and human health.

Table 1: According to years, heavy metal concentrations in *R. kanagurta* (µg g^{-1})

Tissue	Year	N	Ni (X±SD)	Pb (X±SD)	Cd (X±SD)	Cr (X±SD)	N	Ni (X±SD)	Pb (X±SD)	Cd (X±SD)	Cr (X±SD)
			Autumn					Winter			
Muscle	I	20	0.26±0.19	0.21±0.18	0.17±0.16	0.16±0.10	26	0.20±0.18	0.18±0.17	0.18±0.17	0.35±0.17
	II	22	0.31±0.17	0.18±0.15	0.17±0.14	0.34±0.18	25	0.28±0.22	0.21±0.21	0.26±0.18	0.32±0.20
	III	22	0.47±0.22	0.10±0.05	0.34±0.33	0.22±0.21	24	0.37±0.27	0.37±0.21	0.32±0.27	0.30±0.25
	IV	20	0.28±0.18	0.24±0.19	0.22±0.20	0.33±0.08	24	0.30±0.15	0.29±0.26	0.34±0.30	0.12±0.06
	V	22	0.30±0.18	0.24±0.22	0.15±0.10	0.45±0.23	20	0.36±0.22	0.28±0.25	0.27±0.11	0.41±0.21
Liver	I	20	1.16±0.43	0.65±0.24	1.27±0.47	0.57±0.30	26	0.54±0.52	0.47±0.24	1.26±0.46	0.72±0.51
	II	22	0.47±0.47	0.69±0.50	1.26±0.48	0.63±0.32	25	0.63±0.47	0.73±0.46	1.32±0.59	0.64±0.34
	III	22	1.45±0.42	1.14±0.53	0.95±0.76	0.57±0.21	24	1.26±0.33	1.27±0.36	1.03±0.63	0.63±0.40
	IV	20	1.27±0.38	1.35±0.50	1.57±0.80	0.52±0.36	24	1.33±0.36	1.34±0.53	1.81±0.51	0.46±0.18
	V	22	2.11±0.60	1.21±0.43	1.52±0.74	0.55±0.28	20	2.18±0.54	1.35±0.41	1.24±0.59	0.63±0.34
Kidney	I	20	0.35±0.29	0.07±0.06	0.13±0.07	0.10±0.06	26	0.44±0.27	0.16±0.15	0.18±0.081	0.15±0.06
	II	22	0.43±0.32	0.13±0.06	0.17±0.16	0.18±0.06	25	0.40±0.24	0.06±0.17	0.22±0.16	0.17±0.08
	III	22	0.47±0.35	0.23±0.13	0.26±0.17	0.26±0.24	24	0.40±0.22	0.22±0.18	0.24±0.15	0.34±0.21
	IV	20	0.71±0.47	0.24±0.18	0.21±0.19	0.47±0.23	24	0.43±0.31	0.41±0.24	0.25±0.22	0.31±0.18
	V	22	0.52±0.54	0.49±0.19	0.38±0.26	0.29±0.21	20	0.81±0.49	0.52±0.19	0.36±0.22	0.40±0.27
Gill	I	20	0.23±0.136	0.06±0.06	0.42±0.17	0.09±0.07	26	0.29±0.17	0.09±0.02	0.28±0.12	0.09±0.06
	II	22	0.25±0.16	0.21±0.14	0.45±0.14	0.15±0.04	25	0.36±0.19	0.25±0.06	0.36±0.18	0.19±0.06
	III	22	0.34±0.12	0.34±0.18	0.36±0.14	0.36±0.14	24	0.36±0.16	0.25±0.18	0.28±0.19	0.41±0.21
	IV	20	0.38±0.20	0.36±0.22	0.61±0.17	0.36±0.14	24	0.54±0.18	0.25±0.23	0.46±0.22	0.41±0.21
	V	22	0.36±0.20	0.23±0.16	0.55±0.31	0.43±0.23	20	0.20±0.30	0.48±0.28	0.51±0.25	0.35±0.14
Gonad	I	20	0.30±0.29	0.22±0.20	0.17±0.14	0.21±0.05	26	0.39±0.30	0.23±0.22	0.15±0.11	0.19±0.17
	II	22	0.49±0.20	0.36±0.27	0.35±0.15	0.30±0.24	25	0.41±0.26	0.28±0.22	0.36±0.18	0.46±0.21
	III	22	0.56±0.23	0.39±0.20	0.38±0.26	0.51±0.22	24	0.68±0.30	0.55±0.21	0.31±0.12	0.43±0.24
	IV	20	0.43±0.22	0.54±0.23	0.43±0.23	0.52±0.24	24	0.44±0.51	0.60±0.19	0.49±0.23	0.36±0.19
	V	22	0.78±0.62	0.62±0.22	0.52±0.33	0.51±0.38	20	1.25±0.41	0.42±0.29	0.31±0.20	0.46±0.22
	Season		**Spring**					**Summer**			
Muscle	I	18	0.22±0.21	0.35±0.19	0.25±0.20	0.48±0.22	22	0.29±0.28	0.27±0.17	0.19±0.28	0.31±0.17
	II	20	0.34±0.23	0.44±0.36	0.23±0.19	0.49±0.24	24	0.47±0.19	0.35±0.26	0.15±0.29	0.26±0.21
	III	20	0.52±0.23	0.40±0.21	0.29±0.26	0.35±0.24	26	0.33±0.23	0.61±0.29	0.36±0.29	0.31±0.21
	IV	18	0.23±0.15	0.38±0.28	0.29±0.27	0.36±0.19	22	0.38±0.28	0.35±0.20	0.44±0.32	0.37±0.58
	V	18	0.23±0.41	0.16±0.25	0.14±0.14	0.50±0.21	21	0.66±0.40	0.30±0.16	0.48±0.10	0.45±0.41
Liver	I	18	1.28±0.46	0.59±0.21	1.26±0.47	0.58±0.37	22	0.55±0.46	0.59±0.36	1.25±0.44	0.58±0.27
	II	20	1.07±0.54	1.19±0.52	1.23±0.74	0.47±0.32	24	1.24±0.53	1.21±0.56	1.41±0.73	0.58±0.27
	III	20	1.42±0.34	1.29±0.53	0.77±0.65	0.66±0.48	26	1.44±0.36	1.24±0.42	1.77±0.63	0.60±0.35
	IV	18	1.81±0.51	1.42±0.52	1.62±0.55	0.54±0.39	22	2.02±0.72	1.45±0.40	1.59±0.57	0.78±0.52
	V	18	2.16±0.56	1.30±0.39	2.07±0.75	0.66±0.49	21	2.26±0.89	1.31±0.56	1.41±0.61	1.52±0.69
Kidney	I	18	0.38±0.30	0.16±0.08	0.13±0.09	0.21±0.06	22	0.38±0.26	0.05±0.12	0.15±0.11	0.26±0.06
	II	20	0.42±0.26	0.22±0.10	0.18±0.13	0.21±0.08	24	0.54±0.26	0.24±0.15	0.23±0.17	0.41±0.21
	III	20	0.46±0.30	0.55±0.27	0.24±0.20	0.31±0.27	26	0.95±0.47	0.35±0.24	0.23±0.23	0.23±0.22
	IV	18	0.43±0.62	0.54±0.24	0.21±0.12	0.31±0.24	22	0.62±0.59	0.49±0.22	0.33±0.20	0.50±0.27
	V	18	1.52±0.53	0.58±0.21	0.24±0.22	0.46±0.25	21	1.73±0.53	0.47±0.17	0.41±0.23	0.56±0.24
Gill	I	18	0.35±0.20	0.12±0.03	0.32±0.21	0.15±0.06	22	0.34±0.20	0.14±0.02	0.36±0.22	0.15±0.06
	II	20	0.30±0.15	0.46±0.23	0.28±0.19	0.38±0.19	24	0.21±0.15	0.19±0.18	0.51±0.21	0.26±0.13
	III	20	0.36±0.19	0.29±0.22	0.53±0.17	0.43±0.19	26	0.41±0.19	0.24±0.21	0.54±0.24	0.31±0.16
	IV	18	0.36±0.16	0.28±0.23	0.62±0.26	0.43±0.19	22	0.41±0.22	0.33±0.29	0.53±0.35	0.31±0.16
	V	18	0.15±0.31	0.63±0.15	0.45±0.25	0.44±0.21	21	0.52±0.37	0.61±0.24	0.48±0.39	0.47±0.22
Gonad	I	18	0.34±0.20	0.41±0.37	0.17±0.10	0.23±0.06	22	0.45±0.24	0.33±0.25	0.16±0.15	0.24±0.21
	II	20	0.46±0.21	0.51±0.22	0.27±0.16	0.40±0.20	24	0.41±0.24	0.52±0.25	0.47±0.19	0.41±0.15
	III	20	0.57±0.42	0.48±0.19	0.40±0.29	0.52±0.18	26	0.69±0.49	0.62±0.19	0.47±0.18	0.57±0.23
	IV	18	0.68±0.33	0.54±0.22	0.58±0.18	0.65±0.17	22	0.59±0.45	0.65±0.15	0.41±0.22	0.53±0.22
	V	18	0.64±0.45	0.51±0.18	0.52±0.19	0.50±0.18	21	1.22±0.54	0.63±0.23	0.63±0.29	0.42±0.21

I:2006-2007; **II**:2007-2008; **III**:2008-2009; **IV**:2009-2010; V:2010-2011

Table 2: According to seasons, heavy metal concentrations in *R. kanagurta* (µg g^{-1})

Tissue	Season	Muscle	Liver	Kidney	Gill	Gonad
	Autumn	0.35±0.20 ^{ax}	1.26±0.67 ^{b}	0.56±0.45 ^{cxy}	0.34±0.18 ^{a}	0.57±0.40 ^{d}
	Winter	0.35±0.22^{ay}	1.21±0.62 ^{bxy}	0.53±0.34 ^{czw}	0.40±0.19 ^{a}	0.66±0.46 ^{d}
Ni	Spring	0.37±0.28 ^{az}	1.50±0.64 ^{bxz}	0.77±0.64 ^{cxz}	0.40±0.22 ^{a}	0.59±0.37 ^{d}
	Summer	0.49±0.32^{axyz}	1.46±0.82 ^{b}	0.90±0.63 ^{cyw}	0.41±0.26 ^{a}	0.70±0.47 ^{d}
	Total	0.39±0.26^{a}	1.35±0.70 ^{b}	0.69±0.55 ^{b}	0.39±0.21 ^{a}	0.64±0.43 ^{b}
	Autumn	0.23±0.19^{abxyz}	1.08±0.54 ^{c}	0.25±0.19 ^{axy}	0.26±0.23 ^{bxy}	0.44±0.26 ^{dx}
	Winter	0.30±0.24^{ab}	1.03±0.50 ^{c}	0.31±0.24 ^{a}	0.28±0.26 ^{bz}	0.44±0.28 ^{dy}
Pb	Spring	0.37±0.28^{abx}	1.13±0.52 ^{c}	0.38±0.26 ^{ax}	0.38±0.26 ^{bxz}	0.49±0.23 ^{d}
	Summer	0.37±0.28 ^{abyz}	1.14±0.54 ^{c}	0.37±0.25 ^{ay}	0.36±0.28 ^{by}	0.55±0.25 ^{dxy}
	Total	0.32±0.26 ^{a}	1.09±0.53 ^{b}	0.33±0.24 ^{a}	0.32±0.27 ^{a}	0.48±0.26 ^{c}
	Autumn	0.26±0.23 ^{ax}	1.25±0.68 ^{cx}	0.27±0.22 ^{a}	0.48±0.22 ^{b}	0.41±0.27 ^{b}
	Winter	0.31±0.27 ^{ab}	1.26±0.63 ^{cy}	0.27±0.21 ^{ab}	0.41±0.22 ^{dx}	0.33±0.21 ^{b}
Cd	Spring	0.28±0.23 ^{ab}	1.37±0.73 ^{c}	0.25±0.18 ^{a}	0.44±0.23 ^{d}	0.41±0.24 ^{b}
	Summer	0.37±0.36 ^{abx}	1.52±0.66 ^{cxy}	0.30±0.21 ^{a}	0.52±0.30 ^{dx}	0.43±0.25 ^{b}
	Total	0.31±0.29 ^{a}	1.35±0.68 ^{b}	0.27±0.21 ^{a}	0.46±0.25 ^{c}	0.40±0.25 ^{d}
	Autumn	0.33±0.24 ^{abx}	0.63±0.30 ^{dx}	0.29±0.24 ^{acx}	0.30±0.21 ^{bc}	0.40±0.27 ^{e}
	Winter	0.31±0.23 ^{aby}	0.71±0.39 ^{c}	0.28±0.23 ^{ay}	0.26±0.20 ^{bx}	0.39±0.23 ^{d}
Cr	Spring	0.44±0.24 ^{axy}	0.76±0.43 ^{c}	0.32±0.27 ^{b}	0.33±0.22 ^{b}	0.47±0.25 ^{a}
	Summer	0.40±0.29 ^{abc}	0.89±0.56 ^{dx}	0.41±0.28 ^{axy}	0.33±0.21 ^{cx}	0.44±0.24 ^{b}
	Total	0.37±0.26 ^{a}	0.75±0.44 ^{b}	0.32±0.26 ^{a}	0.30±0.21 ^{a}	0.42±0.25 ^{c}

^{a,b,c,d,e} Different letter in the same row indicate significant differences in metal concentration between tissues ($p<0.05$)
^{x,y,z,w} same letter in the row (total except) indicate not significant differences in metal concentration between season ($p<0.05$)

Table 3: Heavy metal concentrations in *R. kanagurta* (µg g^{-1})

Tissue	Metal			
	Ni(X±SD)	Pb(X±SD)	Cd(X±SD)	Cr(X±SD)
Muscle	0.39±0.26 (0.01-1.68)	0.32±0.26 (0.01-1.02)	0.31±0.28 (0.01-1.84)	0.39±0.25 (0.01-1.96)
Liver	1.35±0.70 (0.16-3.96)	1.09±0.53 (0.11-2.77)	1.35±0.68 (0.01-2.98)	0.75±0.44 (0.06-3.64)
Kidney	0.69±0.55 (0.01-2.83)	0.33±0.24 (0.01-0.97)	0.27±0.21 (0.01-0.96)	0.32±0.26 (0.01-1.16)
Gill	0.39±0.21 (0.12-1.52)	0.32±0.27 (0.01-1.21)	0.46±0.25 (0.10-1.68)	0.30±0.21 (0.01-1.08)
Gonad	0.64±0.43 (0.02-2.23)	0.48±0.26 (0.01-1.31)	0.40±0.24 (0.01-1.06)	0.42±0.25 (0.01-1.06)

Table 4: Comparison of concentration in fish tissues

Locations/Limits	Tissue	Metal and concentrations (µg g^{-1})				Studies
		Ni	Pb	Cd	Cr	
Versova	Msc	-	0.013	0.019	-	Deshpande *et al.* 2009
Sasson		-	0.01	0.007	-	
Navi Mumbai		-	0.24	0.01	-	
Mazgaon		-	0.026	-	-	
India	Msc	9.09	0.34	3.11	-	Rejomon *et al*. 2010
India	Msc	-	-	0.73	-	Mukherjee and Bhupander, 2011
Kalpakkam	Msc	-	0.91	-	0.68	Biswas *et al.* 2012
	Msc					Victor *et al*. 2012
	Liv	-	0.863	0.506	-	
Wet markets	Kid	-	1.062	1.212	-	
	Gill	-	1.289	1.366	-	
	Gnd	-	1.482	1.461	-	
Persion Gulf	Msc	0.194	0.392	0.112	-	Khoshnood *et al.* 2012
	Gill	0.342	0.943	0.197	-	
	Liv	0.451	1.341	0.262	-	
India	Msc	-	-	0.162	-	Bhupander *et al.* 2012
Kalpakkam region	Msc	-	1.85	0.87	-	
St 1	Gill	-	2.13	3.18	-	
	Liv	-	5.78	2.60	-	
Kalpakkam region	Msc	-	2.97	1.12	-	Saravanamurugan *et al*. 2013
St 2	Gill	-	6.21	6.44	-	
	Liv	-	7.98	8.18	-	
International		-	2	1.00	50	WH0 1989
Limits		-	0.50	0.50	-	FAO 1983

Table 5: The estimated daily and weekly intakes for the economically important fish species consumed by adult people in Pakistan

Metal	PTWI	PTWI*[b]	PTDI[c]	*Rastrelliger kanagurta*EWI[d] (EDI)[e]
Ni	35[a]	2100	300.00[f]	12.87 (1.84)
Pb	25[a]	1500	214.29	10.56 (1.51)
Cd	7[a]	420	60.00	10.23 (1.46)

* Provisional Permissible Tolerable Weekly Intake (PTWI) in l g/week/kg body weight.Mean weekly fish consumption in Pakistan is 33 g per person (Chughtai and Mahmood, 2012)[a] (FAO/WHO, 2004). [b] PTWI for 60 kg adult person (lg/week/60 kg body weight).[c] PTDI, permissible tolerable daily intake (lg/day/60 kg body weight).[d] EWI, estimated weekly intake in lg/week/60 kg body weight.[e] EDI, estimated daily intake in lg/day/60 kg body weight.

ACKNOWLEDGMENTS

We would like to thank all the referees, who have added value to our paper with their through reviews.

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