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Lead concentrations in Fresh Water, Muscle, Gill and Liver of *Catla catla* (Hamilton) from Keenjhar Lake

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Abstract

This study of the abundance and distribution of lead in water and freshwater fish *Catla catla* (Ham.) from Keenjhar Lake was conducted during January 2003 to December 2005. The lead content was determined in water and in muscle, gill and liver tissue of *Catla catla* (Ham.) by using a graphite furnace atomic absorption spectrometry. The lead concentrations in water samples were in the range of 0.076 and 0.225 µg L^{-1} during the years of 2003, 2004 and 2005. The lead concentrations in the tissues of *Catla catla* (Ham.) varied, with liver > gill > muscle. The concentrations in muscle, gill and liver were in the range of 0.7-2.39 µg g^{-1}, 0.74-2.25 µg g^{-1} and 0.89-2.68 µg g^{-1} (dry weight) during 2003, 2004 and 2005. 9.87 % did not exceed the UK limit of 1.0 µg g^{-1} (1979), 45.67 % were lower than the (USFDA) level of 1.3 µg g^{-1} (USEPA 1997) and remaining 44.46 % were well below than 4.88 µg g^{-1} (USEPA 1990). The levels in the water samples were also below the permissible level of ≤ 50 µg L^{-1} recommended by (WHO 1984).

Keywords: *Water, Lead, Catla catla, Keenjhar Lake.*

Introduction

The determination of trace metal concentration in natural water system has received increasing attention for monitoring environmental pollution, due to the fact that some metals are not biodegradable and their way in food chain through a number of path ways and may accumulate in different organs of human beings or animals [1]. The metals like cobalt, copper, manganese, zinc, nickel and lead are essential micronutrients at trace level, but are toxic if present in higher concentration [2].

Heavy metals like chromium, copper, zinc, nickel and lead are some of the major components of the industrial wastes, which along with other products from industrial operations are discharged into the aquatic environment. These substances are toxic to aquatic life [3-5]. Metals have the tendency to accumulate in various organs of the aquatic organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards [6]. Chromium, lead, mercury, zinc, copper and nickel are among the most harmful metallic pollutants. Bioaccumulation of these metals is known to adversely affect liver, muscle, kidney and other tissues of fish, disturb metabolism and hamper development and growth of fish [7-9].

Where as metals like lead, cadmium, arsenic, and chromium are heavy metals and are toxic, the higher concentration of these metals than maximum recommended concentration may affect adversely the living organism [10]. Lead is a microelement naturally present in trace amounts in all biological materials in soil, water, plants and animals [11]. It has no physiological function in the organism [12, 13]. The main source of lead contamination are smelting works, application of waste water treatment sludge's to soil, transportation, rain, snow, hail and other, approximately 98% of lead in the atmosphere originates from the human activates [14]. Lead can be taken in by eating food, drinking water or breathing air children and to lesser extent, adults can also be exposed by ingesting soil.

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Bio monitoring of trace metal pollution has been gaining attention, since various organisms have the ability to accumulate these substances and transfer them in a large concentration to animals and human beings when consumed [15]. Keenjhar Lake is significant source of drinking water and rich in fishery potential [8]. Keenjhar Lake is artificial tropical lake [16] it is situated nearly 120 Km (24˚47'N: 68˚2'E) from Karachi, [17]. Inlet source of Keenjhar Lake is canal "Kalri Bhaggar Feeder" originating from Ghulam Mohammad Barrage, River Indus (Fig. 1).

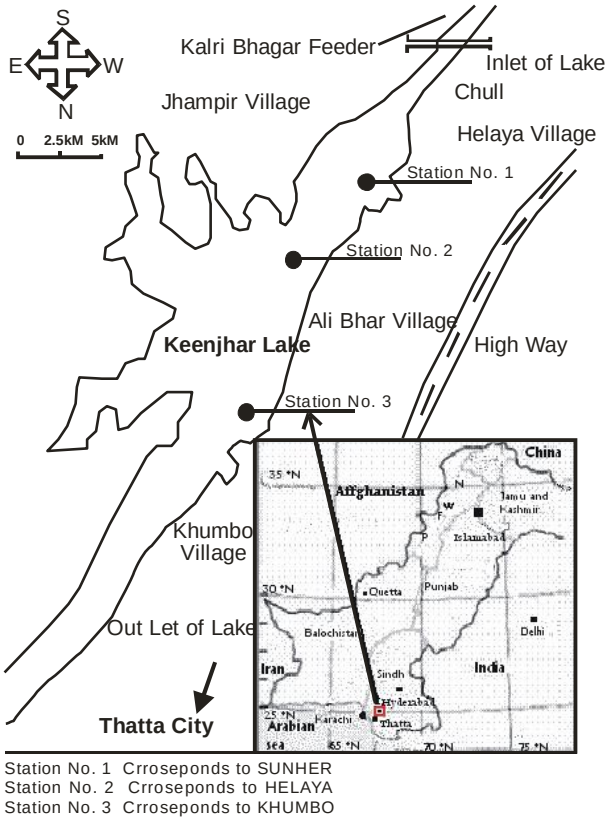

Fig. 1. **The position of three selected stations at Keenjhar Lake**

Determination of lead in water samples was done due to drinking source of local population of Karachi. Samples from muscles, gill and liver of *Catla catla* (Ham.) were used owing to the economical value of *Catla catla* (Ham.) to indicate biomarker of lead toxicity from Keenjhar Lake. Present study was conducted as the first time for the Keenjhar Lake.

Materials and Methods

Sampling and pretreatment

Water samples as well as *Catla catla* (Ham.) were collected from three stations of Keenjhar Lake **1.** Sunheri, **2.** Helaya and **3.** Khumbo**,** during January 2003 to December 2005 on monthly basis. Water samples collected from surface and bottom layers by using Van Dorn plastic bottles (1.5 mL capacity) from 5 spots of each station randomly were kept in polythene plastic bottles, previously soaked in 10% nitric acid for 24 h and rinsed with ultra pure water obtained from ELGA Lab water system.

The fish samples *Catla catla* (Ham.) the most frequently found in Keenjhar Lake and caught by gill net (Mesh 2.0-2.5 cm) from selected three stations of Keenjhar Lake on each month. The total samples of fish, collected with weight ranges (260-380 grams) mean weight (±SD) of *Catla catla* (Ham.) are given in, Table 1, from selected three stations, almost 36 individual samples were collected yearly from each sampling station of Keenjhar Lake. All obtained fish samples were packed in polythene bags separately and tagged. At the end of apiece sampling attempt all water and fish samples were stored in an insulated cooler containing ice and delivered the same day to the laboratory and all samples were kept at 4 ˚C until processing and analysis.

On returning to the laboratory, the 5 samples from each spot were mixed into a washed plastic bucket to make a complex sample, after this the mixture was filtered through filter paper (Whatman 42) with the help of vacuum pump. This complex was acidified with HNO_3 for heavy metal deduction.

Gills, liver and muscles samples (Cut next to dorsal fin) were removed from the fish packed in baking foil (Diamond Aluminum Foil. U.S.A) and dried in an oven (Model N53C. England) at 100˚C for 8 h.

Regents and glassware

Ultrapure water obtained from ELGA Labwater System (Bucks, UK) was used throughout the present work; nitric acid and hydrogen peroxide were of grade (Merck) and was checked for possible trace element contamination. Standard solution of lead was prepared by dilution of certified standard solution (1000 ppm, Fluka Kamica, and Switzerland) of corresponding metal ions. Standard reference materials SRM 1643e (Water) were purchased from National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA. DROM-2 (fish muscles) was obtained from National Research Council Canada. Argon gas with 99.9 % purity was used as sheath gas for the atomizer

and for internal purge. Glassware were kept overnight in 5 M HNO_3 rinsed with de ionized water before use.

Table 1. **Mean weight with (± SD) of *Catla catla* (Ham.) caught during present study from selected stations.**

	2003	2004	2005
Station 1.	334.09±53.3 g.	300.92±49.7 g.	326.46±48.6 g.
Station 2.	317.54±66.9 g.	334.25±57.5 g.	268.22±32.9 g.
Station 3.	308.38±37.7 g.	356.88±59.01 g.	301.16±31.1 g.

Apparatus

Polytetrafluoroethylene (PTFE) tubes having a volume of 50 mL were used for dissolving the fish samples, an electric hot plate 80 ˚C (Model ARE Velp. Italy) was used for acid digestion of fish tissues samples. Atomic absorption spectrometer of Hitachi Ltd., Model 180-50, S.N. 5721-2 with a deuterium lamp back corrector equipped with a 10 cm burner head and graphite furnace GA-03. Hitachi Model 056 recorder was used for recording analytical data for the lead under investigation. Hollow cathode lamps were used as radiation sources. Analytical parameters are specified in Table 2.

Table 2. **Measurement conditions for atomic absorption spectrometer**

Electrothermal atomic absorption (ETAAS).	
Lamp current (mA)	7.5
Wave Length (nm)	283.3
Slit-Width (nm)	1.3
Cuvette	Tube
Dry	80-120/15[a]
Ash	300-600/15[a]
Atomization	2000-2100/5[a]
Cleaning	2100-2400/2[a]
Chemical modifier	Mg $(NO_3)_2$
Carrier gas 200mL/min and sample volume 10µL + 10µL modifier for Lead.	

[a] Temperature range ˚C/time (s).

Analytical procedure

Lake water

The analytical data quality was ensured through careful standardization, procedural blank measurement, and duplicate samples. Ten percent of the acid treated complex water samples were duplicated as a quality assurance requirement. For lead analysis, 500 mL of water samples were pre concentrated 20 times by heating at 80˚C on electric hot plate (Model ARE Velp. Italy) and covered with watch glasses which result in slight boiling of sample. After heating for 30 minutes 5 mL HNO_3 (Merck) was added, transparent solution was obtained. The content of flask was chilled and diluted with 2.0 M HNO_3 (Merck) and filtered by filter paper (Whatman 42) put together to 25 mL in PTFE covered tube and kept under 4˚C for further analysis as stock solution.

Dissolution of fish samples for metal analysis

0.2 grams, dried content of gill, liver and muscles were digested in a mixture of (HNO_3 10 mL and H_2O_2 5 mL, 2:1 ratio); than it was heated on electric hot plate 80 ˚C (Model ARE Velp. Italy) for digestion, 10 mL of 2M HNO_3 (Merck) was added prior to digestion, filtered by filter paper (Whatman 42) and kept under 4˚C for further atomic absorption analysis [18].

Data treatment by statistical method

One-way Analysis of variance (ANOVA) was performed [19].

Quality control

Quality control, analytical blanks and certified samples with known concentrations of lead were prepared and analyzed using the same procedure and regents. For the accuracy of the determination procedure, it was assessed by triplicate analysis of certified reference materials of water (SRM 1643e) and fish (DORM-2). Their certified values and observed values are given in Table 3.

Table 3. **Analytical results of certified reference materials**

	Water (SRM 1643e)		**Fish (DORM-2)**	
	Certified values. (µg L^{-1})	***Our values. (µg L^{-1})***	***Certified values (mg kg^{-1})***	***Our values. (mg kg^{-1})***
Lead	19.63±0.21	19.52±0.35	0.065±0.007	0.066±0.008

Results

Lake water analysis

The monthly concentrations of lead in water samples remained below the WHO standard of ≤ 50 µg

L^{-1} and the total mean concentration of Pb ≥ 0.04 μg L^{-1} was considerably lower during the present study. The monthly variation of lead in water samples from Keenjhar Lake during 2003 is shown in Table V, with a maximum lead concentration of 0.235 μg L^{-1}. The monthly variation during 2004 is shown in Table VI, with a maximum lead concentration of 0.225 μg L^{-1}. During 2005 the maximum lead concentration was 0.225 μg L^{-1}, compared with the WHO standard of ≤ 50 μg L^{-1}, as shown in Table VII. No sequenced data from water samples was observed during the present study.

Fish samples analysis

The moisture content % (Mean±SD) from tissues (Muscle, gill and liver) of *Catla catla* (Ham.) is given in Table IV, during present studies. The monthly variations in concentration of lead from tissues of *Catla catla* (Ham.) at respective stations are given in Tables VIII-XVI. Absorption of lead varies between 1.14-2.19 μg g^{-1} (dry weight) during 2003; minimum 1.14 μg g^{-1} was detected from muscles at station 3 and maximum 2.19 μg g^{-1} was observed from liver at station 2. Concentration of lead during 2004 ranges among 1.14-2.21 μg g^{-1} (dry weight), minimum 1.14 μg g^{-1} was detected from muscle at station 3 and maximum 2.2 μg g^{-1} was observed from liver at station 2. During 2005, lead concentration ranged between 0.59-2.68 μg g^{-1} (dry weight), minimum 0.59 μg g^{-1} was observed from muscle at station 2 and maximum 2.68 μg g^{-1} form liver at station 1. The absorbance of lead was high at station 1 during present studies in liver followed by gill and muscle, total mean lead concentration was considerably lower, with $P < 0.005$.

Table 4. **The concentration of lead in water from Stations 1, 2 and 3 during 2003**

	Pb concentration in μg L^{-1} at indicated sampling period: mean (standard deviation)											
Station.	***Jan.***	***Feb.***	***Mar.***	***April***	***May***	***June***	***July***	***Aug.***	***Sep.***	***Oct.***	***Nov.***	***Dec.***
1	0.215 (0.007)	0.235 (0.03)	0.185 (0.007)	0.215 (0.007)	0.185 (0.007)	0.185 (0.007)	0.205 (0.007)	0.22 (0.04)	0.195 (0.02)	0.225 (0.007)	0.195 (0.007)	0.215 (0.007)
2	0.175 (0.007)	0.155 (0.007)	0.13 (0.01)	0.125 (0.007)	0.105 (0.007)	0.125 (0.007)	0.13 (0.01)	0.125 (0.03)	0.00.125 (0.007)	0.13 (0.01)	0.14 (0.01)	0.1 (0.01)
3	0.095 (0.007)	0.105 (0.21)	0.12 (0.01)	0.105 (0.02)	0.09 (0.01)	0.105 (0.03)	0.104 (0.008)	0.093 (0.006)	0.115 (0.02)	0.09 (0.004)	0.105 (0.02)	0.093 (0.006)

Table 5. **The concentration of lead in water from Stations 1, 2 and 3 during 2004**

	Pb concentration in μg L^{-1} at indicated sampling period: mean (standard deviation)											
Station	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
1	0.22 (0.01)	0.215 (0.007)	0.2 (0.01)	0.205 (0.007)	0.2 (0.01)	0.225 (0.007)	0.2 (0.01)	0.215 (0.007)	0.21 (0.03)	0.2 (0.03)	0.22 (0.01)	0.215 (0.02)
2	0.125 (0.007)	0.085 (0.007)	0.115 (0.007)	0.085 (0.007)	0.125 (0.007)	0.105 (0.02)	0.09 (0.01)	0.115 (0.04)	0.11 (0.03)	0.093 (0.006)	0.125 (0.007)	0.084 (0.007)
3	0.13 (0.01)	0.11 (0.03)	0.083 (0.004)	0.108 (0.01)	0.109 (0.03)	0.1 (0.03)	0.109 (0.03)	0.077 (0.003)	0.093 (0.006)	0.105 (0.02)	0.115 (0.007)	0.114 (0.02)

Table 6. **The concentration of lead in water from Stations 1, 2 and 3 during 2005**

Pb concentration in µg L^{-1} at indicated sampling period: mean (standard deviation)												
Station	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
1	0.215 (0.007)	0.21 (0.03)	0.195 (0.02)	0.225 (0.007)	0.185 (0.007)	0.205 (0.007)	0.22 (0.01)	0.185 (0.007)	0.22 (0.007)	0.215 (0.007)	0.185 (0.007)	0.205 (0.007)
2	0.135 (0.007)	0.098 (0.02)	0.098 (0.03)	0.12 (0.01)	0.094 (0.005)	0.1 (0.03)	0.105 (0.007)	0.125 (0.007)	0.089 (0.01)	0.097 (0.001)	0.099 (0.03)	0.099 (0.001)
3	0.092 (0.007)	0.11 (0.01)	0.092 (0.008)	0.0115 (0.02)	0.109 (0.02)	0.076 (0.007)	0.125 (0.007)	0.093 (0.006)	0.108 (0.02)	0.115 (0.02)	0.093 (0.006)	0.109 (0.02)

Table 7. **Moisture content % (Mean ± SD) form tissues of *Catla catla* (Ham.) during present study**

	2003		**2004**		**2005**	
	Minimum	***Maximum***	***Minimum***	***Maximum***	***Minimum***	***Maximum***
Muscle	79.69±0.38	82.49±1.52	81.1±0.78	83.54±1.8	80.19±0.34	83.39±0.76
Gill	79.43±2.5	81.6±1.75	78±2.95	83.46±3.3	74.31±2.75	84.48±2.62
Liner	76.21±0.5	80.05±0.23	76.38±1.9	80.8±1.01	69.2±2.32	82.6±1.2

Table 8. **The concentration of lead in from Station 1 in muscle, gill and liver during 2003.**

Pb concentration in µg g^{-1} (dry weight) at indicated sampling period: mean (standard deviation)												
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.28 (0.05)	1.59 (0.08)	1.65 (0.03)	1.41 (0.03)	1.46 (0.05)	1.51 (0.05)	1.44 (0.03)	1.23 (0.03)	1.47 (0.03)	1.57 (0.05)	1.47 (0.03)	1.5 (0.08)
Gill	1.57 (0.06)	1.87 (0.05)	1.91 (0.03)	1.71 (0.03)	1.79 (0.03)	1.7 (0.05)	1.73 (0.03)	1.47 (0.03)	1.91 (0.03)	1.71 (0.03)	1.58 (0.06)	1.78 (0.05)
Liver	2.05 (0.05)	1.93 (0.06)	2.14 (0.06)	2.07 (0.06)	2.04 (0.05)	1.91 (0.03)	2.04 (0.05)	1.65 (0.03)	2.12 (0.03)	1.95 (0.05)	1.73 (0.03)	2.09 (0.03)

Table 9. **The concentration of lead from Station 2 in muscle, gill and liver during 2003.**

Pb concentration in µg g^{-1} (dry weight) at indicated sampling period: mean (standard deviation)												
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.44 (0.03)	1.59 (0.03)	1.47 (0.03)	1.62 (0.03)	1.55 (0.05)	1.23 (0.03)	1.32 (0.03)	1.38 (0.03)	1.2 (0.06)	1.57 (0.05)	1.32 (0.03)	1.38 (0.03)
Gill	1.62 (0.03)	1.94 (0.03)	1.68 (0.03)	1.71 (0.06)	1.73 (0.03)	1.5 (0.06)	1.47 (0.06)	1.68 (0.03)	1.45 (0.05)	1.74 (0.05)	1.52 (0.05)	1.62 (0.03)
Liver	1.74 (0.05)	2.19 (0.06)	1.91 (0.03)	1.97 (0.06)	2.09 (0.03)	1.74 (0.05)	1.78 (0.05)	1.99 (0.05)	1.77 (0.06)	1.95 (0.05)	1.8 (0.07)	1.87 (0.05)

Table 10. **The concentration of lead from Station 3 in muscle, gill and liver during 2003.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.14 (0.03)	1.48 (0.05)	1.29 (0.03)	1.14 (0.03)	1.29 (0.03)	1.38 (0.03)	1.18 (0.05)	1.2 (0.03)	1.3 (0.06)	1.44 (0.03)	1.44 (0.03)	1.53 (0.03)
Gill	1.45 (0.05)	1.76 (0.03)	1.68 (0.03)	1.56 (0.06)	1.47 (0.06)	1.65 (0.03)	1.53 (0.03)	1.41 (0.03)	1.56 (0.03)	1.66 (0.05)	1.7 (0.05)	1.85 (0.03)
Liver	1.73 (0.03)	2.13 (0.05)	1.94 (0.03)	1.82 (0.03)	1.87 (0.05)	1.88 (0.03)	1.8 (0.06)	1.76 (0.03)	1.9 (0.05)	1.99 (0.05)	2.16 (0.05)	2.12 (0.03)

Table 11. **The concentration of lead from Station 1 in muscle, gill and liver during 2004.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.6 (0.05)	1.5 (0.03)	1.3 (0.06)	1.3 (0.03)	1.4 (0.05)	1.4 (0.03)	1.7 (0.03)	1.4 (0.03)	1.36 (0.05)	1.62 (0.03)	1.53 (0.03)	1.6 (0.03)
Gill	1.8 (0.08)	1.7 (0.03)	1.4 (0.05)	1.5 (0.03)	1.7 (0.03)	1.5 (0.06)	1.9 (0.05)	1.7 (0.05)	1.6 (0.05)	1.9 (0.03)	1.9 (0.05)	1.8 (0.03)
Liver	2.13 (0.05)	2.01 (0.06)	1.73 (0.03)	1.73 (0.03)	1.84 (0.06)	1.91 (0.03)	2.2 (0.05)	2.2 (0.05)	1.88 (0.03)	2.19 (0.06)	2.03 (0.03)	2.12 (0.03)

Table 12. **The concentration of lead from Station 2 in muscle, gill and liver during 2004.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.47 (0.03)	1.44 (0.03)	1.61 (0.05)	1.56 (0.03)	1.62 (0.03)	1.7 (0.05)	1.68 (0.03)	1.58 (0.05)	1.32 (0.03)	1.48 (0.06)	1.44 (0.03)	1.21 (0.05)
Gill	1.66 (0.05)	1.73 (0.03)	1.76 (0.03)	1.73 (0.03)	1.73 (0.03)	1.96 (0.03)	1.94 (0.03)	1.65 (0.03)	1.53 (0.03)	1.74 (0.05)	1.68 (0.03)	1.75 (0.06)
Liver	1.95 (0.05)	1.95 (0.05)	1.95 (0.05)	2.04 (0.05)	2.09 (0.06)	2.21 (0.03)	1.99 (0.05)	1.94 (0.03)	1.91 (0.03)	1.98 (0.05)	1.94 (0.03)	1.95 (0.05)

Table 13. **The concentration of lead from Station 3 in muscle, gill and liver during 2004.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.44 (0.03)	1.2 (0.03)	1.62 (0.03)	1.2 (0.08)	1.35 (0.03)	1.38 (0.03)	1.2 (0.03)	1.23 (0.03)	1.14 (0.03)	1.14 (0.03)	1.14 (0.03)	1.29 (0.03)
Gill	1.74 (0.05)	1.55 (0.05)	1.89 (0.07)	1.49 (0.06)	1.57 (0.05)	1.67 (0.03)	1.62 (0.05)	1.46 (0.05)	1.4 (0.03)	1.59 (0.03)	1.44 (0.03)	1.47 (0.03)
Liver	1.95 (0.05)	1.73 (0.03)	2.03 (0.03)	1.8 (0.07)	1.73 (0.03)	1.94 (0.03)	1.79 (0.03)	1.76 (0.03)	1.7 (0.05)	1.91 (0.03)	1.68 (0.03)	1.82 (0.03)

Table 14. **The concentration of lead from Station 1 in muscle, gill and liver during 2005.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.25 (0.07)	1.53 (0.1)	1.06 (0.03)	1.2 (0.06)	0.7 (0.06)	1.06 (0.1)	1.91 (0.06)	1.33 (0.09)	2.39 (0.09)	1.58 (0.12)	0.99 (0.05)	1.5 (0.08)
Gill	1.52 (0.09)	1.7 (0.03)	1.87 (0.09)	1.57 (0.06)	0.99 (0.07)	1.33 (0.03)	1.79 (0.12)	1.62 (0.1)	1.79 (0.08)	2.25 (0.12)	1.23 (0.06)	1.26 (0.12)
Liver	1.8 (0.1)	2.05 (0.06)	2.15 (0.06)	1.85 (0.06)	1.24 (0.06)	1.48 (0.09)	2.11 (0.1)	1.77 (0.03)	2.68 (0.09)	2.42 (0.09)	1.57 (0.12)	2.05 (0.05)

Table 15. **The concentration of lead from Station 2 in muscle, gill and liver during 2005.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.57 (0.06)	1.36 (0.1)	0.7 (0.1)	1.3 (0.06)	0.9 (0.07)	0.59 (0.06)	0.97 (0.08)	0.97 (0.08)	0.75 (0.07)	1.03 (0.1)	1.02 (0.05)	1.03 (0.1)
Gill	1.8 (0.1)	1.6 (0.03)	1.07 (0.05)	1.42 (0.07)	1.17 (0.06)	0.74 (0.03)	1.28 (0.05)	1.19 (0.09)	1.41 (0.06)	1.34 (0.06)	1.06 (0.06)	1.32 (0.09)
Liver	2.04 (0.14)	1.79 (0.03)	1.38 (0.1)	1.6 (0.1)	1.5 (0.05)	0.89 (0.06)	1.53 (0.1)	1.48 (0.09)	1.6 (0.05)	1.42 (0.07)	1.28 (0.1)	1.5 (0.06)

Table 16. **The concentration of lead from Station 3 in muscle, gill and liver during 2005.**

	Pb concentration in µg g $^{-1}$ (dry weight) at indicated sampling period: mean (standard deviation)											
	Jan.	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Muscle	1.49 (0.05)	1.04 (0.09)	0.68 (0.06)	0.67 (0.7)	0.71 (0.05)	1.04 (0.07)	1.12 (0.06)	1.02 (0.05)	1.02 (0.05)	1.04 (0.07)	1.19 (0.07)	1.2 (0.07)
Gill	1.42 (0.07)	1.18 (0.06)	0.86 (0.05)	0.93 (0.09)	1.001 (0.08)	1.3 (0.06)	1.18 (0.06)	1.1 (0.07)	1.19 (0.09)	1.25 (0.07)	1.32 (0.09)	1.36 (0.05)
Liver	1.58 (0.05)	1.35 (0.02)	1.18 (0.1)	1.1 (0.06)	1.08 (0.03)	1.4 (0.05)	1.33 (0.03)	1.34 (0.06)	1.35 (0.07)	1.47 (0.1)	1.5 (0.18)	1.42 (0.07)

Discussion

The lead concentration in water samples from station 1 in Keenjhar Lake was extremely high compared with stations 2 and 3 during this study. Station 1 is water sourced from the River Indus inlet through the Kalri Bhaggar feeder canal, which is contaminated with fine particles of heavy metals. At the other stations, fine particles of heavy metals have settled on the rocky bottom of the lake, where a higher uptake of heavy metals would be observed in bottom-feeding aquatic animals. The peak values of lead were 0.235±0.035 µg L^{-1} at station 1 during February 2003, when, owing to the dry season, low rainfall and maximum salinity, trace metals may have been remobilized into the water column due to competition between dissolved captions and absorbed trace metals. The high lead level of 0.225±0.007 µg L^{-1} at station 1 during June 2004 was due to the high temperatures, which enhanced the rate of microbial degradation of organic matter [20]. As a consequence, heavy metals associated with the organic matter are released either into the upper section of the interstitial water column, or dissolved oxygen levels were higher, which resulted in greater decomposition of organic matter. The maximum rate of evaporation and the high lead level of 0.225±0.007 µg L^{-1} at station 1 during April 2005 were due to the high temperatures, low dissolved oxygen, the dry season and low water

volume in lake, with maximum decomposition rates of the organic matter. However, the peak value during the present study was 0.235±0.035 μg $L^{-1,}$ compared with <10 μg L^{-1} in the Calabar River Nigeria [21], but higher than the concentrations observed in Rawal and Mangla Lakes [22] and the River Indus. However, the lead concentration of water from Keenjhar Lake was < 50 μg L^{-1}, as recommended by [23]. No regular pattern in the monthly variation in lead concentration was observed in the water samples.

Of the 324 samples collected of *Catla catla* (Ham.) from Keenjhar Lake at sampling stations over the 3-year study, 9.87 % did not exceed the UK limit for lead in food regulations [24] which is 1.0 μg g^{-1}, 45.67 % of *Catla catla* (Ham.) were lower than the level of 1.3 μg g^{-1} [25]. Food and drug administration guidance/action/tolerance level for fish tissue concentration, and remaining 44.46 % were well below than 4.88 μg g^{-1} [26].

The low lead concentration in the muscle of *Catla catla* (Ham.) in the Keenjhar Lake was due to the low affinity of muscle tissue for heavy metals compared with liver and gill tissue [27, 28]. Reported a lead concentration of 600 μg g^{-1} in pike muscle tissue in a contaminated area of the Rhine River, which was higher than in the present study [29]. In the Alan and Nkap streams in the Ikot Ekpene area of Nigeria, the mean total concentrations of heavy metals in freshwater fish, *Chromiddtilphia guntheri*, were 1.07 μg g^{-1} for Cu and 2.82 μg g^{-1} for Pb [30], which is quite similar to the present study. The amount of lead absorbed was in the order: liver > gills > a muscle during the present study and the lead concentration was higher than in muscle tissue of *Labeo rohita*, *Mystus seenghala* and *Wallago attu* in the Rawal and Mangla lakes [22]. The concentrations of lead were liver > gill > muscle in *Cyprinus carpio*, *Barbus capito* and *Chondostroma regium* from the Seyhan river, Turkey [31, 32], which was higher than the results obtained from station 1 during the present study.

Conclusion

The lead concentration in water and fish depends on the physico-chemical parameters of the water, the rate of decomposition of dead organic material, and the occurrence of dry, rainy and flood seasons. The lead levels in the water of Keenjhar Lake were below the permissible limit of < 50 μg L^{-1} [23], so it is suitable for domestic use.

The muscle tissue of *Catla catla* (Ham.) is suitable for consumption and the gill tissue shows low absorption of lead; however, the lead levels are highest in the liver, though within the permissible limits. The continuous flow of contaminated water into Keenjhar Lake might increase lead levels in the Lake. Although concentrations are low in gill and muscle, they might increase in the future and have adverse effects on consumers.

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