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Study on impact of habitat degradation on proximate composition and amino acid profile of Indian major carps from different habitats

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ABSTRACT

This investigation is aimed to study an impact of habitat degradation on proximate composition and amino acid (AAs) profile of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* collected from polluted, non-polluted area (upstream) and a commercial fish farm. The amino acid profile was estimated by the amino acid analyzer. *C. catla* collected from the polluted environment had highest lipid, protein and ash contents (12.04 ± 0.01, 13.45 ± 0.01 and 0.93 ± 0.03%, respectively). The high protein content (14.73 ± 0.01 and 14.12 ± 0. 01%) was recorded in *C. catla* procured from non-polluted (upstream) wild habitat of River Chenab and controlled commercial fish farm. Farmed fish species showed comparatively higher moisture contents followed by upstream and polluted area fishes. *C. mrigala* showed significant differences in amino acid and proximate composition collected from a polluted site of the river Chenab. *C. catla* collected from non-polluted site of the river showed an excellent nutrient profile, followed by *L. rohita* (wild and farmed) and *C. mrigala* (polluted area), respectively. All fishes from the polluted areas of the River Chenab indicated a significant decrease in the concentration of some AAs when compared to farmed and wild (upstream) major carps. Omitting of some important AAs was also observed in the meat of fish harvested from polluted habitat of this river. *C. mrigala* and *L. rohita* exhibited a significant increase in the concentration of some of non-essential amino acids such as cysteine in their meat. The results indicated that wild fish (upstream) and farmed fish species had highest protein contents and amino acid profile and hence appeared to be the best for human consumption. The proximate composition and AAs profiles of fish harvested from the polluted area of the river clearly indicated that efforts shall be made for the restoration of habitat to continue the requirement of high quality fish meat at a low cost to the human population.

1. Introduction

Freshwater fish is not only the excellent source of animal protein, but also a source of an additional income for a large segment of people living in the adjacent areas of the freshwater reservoirs, particularly in the developing countries (Fawole et al., 2007; Mohammaed and Alim, 2012; Osibona, 2011). The per capita fish supply in Pakistan is 2 kg, which is very low in comparison to the global average, but the demand is increasing steadily. Fish meat contains a significantly lower amounts of saturated fats while higher water contents compared to red meat (Nestel, 2001) and is considered an excellent and cheapest source of polyunsaturated fatty acids of omega series (Stansby, 1982). Fish also contains various essential micronutrients, including various vitamins (A, B and D) and rich in essential amino acids (lysine, methionine, cysteine, threonine and tryptophan) (FAO, 2009). The estimation of fish meat constituents is necessary for the awareness of consumers and formulation of commercial products. The information about the proximate composition and amino acid profiles of fish meat is very important in determining the suitability of fish for its processing and suitability of fish meal as a protein supplement. Such research work may be useful to dieticians for prescription of diets for people with certain medical conditions or those who are health conscious (Ssali, 1988).

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Various researchers have reported the proximate composition and the amino acid profile of different fish species in relation to seasonal and spatiotemporal variations (Gooch et al., 1987; Dustan et al., 1988; Faheem et al., 1991; Chandrashekar and Desosthale, 1993) as well as post-harvest processing, shelf-life of the fish, commercial feed trials and their effects on proximate compositions (Aursand et al., 1994; Clement and Lovelli, 1994; Badiani et al., 1996). Although the knowledge about proximate analysis of fish meat of tropical and subtropical fish species has been well documented. There is no comprehensive information available about the impact of habitat degradation due to pollution and environmental changes on the proximate composition of fish meat and amino acid profile of the freshwater fish species. Water bodies in Pakistan are inhabited by a variety of fish species, providing a good quality white meat and are of enormous economic importance to the country (Osibona, 2011; Mahboob et al., 2014; Mahboob, 2015). The Indian major carps viz., *Catla catla, Labeo rohita* and *Cirrhinus mrigala* are preferred by the consumer due to their taste and quality of meat and are widely cultured in the commercial farms to provide cheap and economical animal proteins. Owing to their economic importance the present study was carried out to determine the proximate composition and amino acid profile to know impact of habitat degradation if any, due to discharge of untreated waste and domestic sewage from the adjacent area of the River Chenab.

2. Materials and methods

2.1. Study area

The River Chenab (31.570° & 72.534°) receives vast amounts of toxic industrial and domestic wastes through the Chakbandi Main Drain. This waste water holds genotoxic and cytotoxic chemicals (Noor and Zutshi, 2016) from a variety of industries in Faisalabad. Wastes disposed through this drain are sufficient to reduce water productivity by changing the physicochemical parameters of the river upstream Trimu Head. This habitat degradation has resulted in retarded growth of aquatic organisms, including Indian major carps.

2.2. Sampling of fish species

35 specimens of each fish species viz., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were collected from each sampling site. The polluted site (PS) was selected around Thatta Muhammad Shah, upstream from the entrance of the drain into the river around Libhan Wala (UC), and from a commercial fish farm (FC) devoid of any contamination. The fish specimens were collected by using gill nets and drag nets. Farmed fish were also collected from a commercial fish farm to compare the proximate composition and amino acid profile of the fish harvested from polluted and non-polluted sampling sites. The weight of the fish specimens collected from each point ranged from 800 to 1150 g. Fish muscle was isolated from the dorso-lateral side of each fish and oven dried at 70 °C for 24 h. Meat samples were then minced and powdered by mortar.

2.3. Proximate analysis

The moisture content in the fish muscle was determined by following the method described by Osibona (2011). The lipid contents were extracted from the minced meat by a Soxhlet extraction unit with n-Hexane at 65 °C. Crude protein content was calculated by a free nitrogen content determined by Kjeldahl's method. Ash contents were determined by incineration of the dried meat samples in the muffle furnace at 525 °C for 36 h (Osibona, 2011). Total carbohydrates were determined by subtracting the sum of% values of crude fat (CF), CP and ash contents (A) from 100 (Mahboob et al., 2014).

2.4. Amino acid analysis

The amino acid profiles of fish meat samples of a three experimental fish species collected from three sampling locations were determined by using the Aracus Amino Acid Analyzer (Membrane Pure, Germany). The amino acids were expressed as g/g of dry matter

2.5. Statistical analysis

The data thus collected were statistically analyzed by One-way analysis of variance. Tukey's multiple comparison tests were used to work out statistically significant differences among the three groups (farmed, upstream and polluted area fishes). All statistical analyses were performed by using SPSS-9 software. The results were reported as mean ± standard error. Significance was checked at $P < 0.05$.

3. Results and discussion

The highest muscle protein contents were recorded as 14.73 ± 0.01% in *C. catla* collected from upstream of the River Chenab (UC), closely followed by the same fish species harvested from a commercial fish farm (FC). Fish collected from polluted sites (PS) of the River Chenab showed higher of lipid contents and lower protein contents. The highest concentration of moisture contents was recorded in the farmed fish (FC) compared to the fish harvested from PS. The high moisture content (73.04 ± 0.02%) was observed in *C. mrigala* collected from FC site. Wild fish from non-polluted area (upstream control = UC) showed highly valuable lipid and protein profiles (Table 1). The highest (12.04 ± 0.01%) and lowest (5.04 ± 0.01%) lipid contents were observed in meat samples of *C. catla* procured from PS and FC sites. The highest (14.57 ± 0.09%) and lowest (9.41 ± 0.02%) ash contents were recorded in *C. mrigala* and *C. catla* procured from PS and FC sites, respectively (Table 1). The highest (1.22 ± 0.16%) and lowest (0.18 ± 0.01%) carbohydrate contents were recorded in *C. catla* and *Labeo rohita* collected from

Table 1
Comparison of means% (±S. E) for proximate composition of three fish species from different experimental areas.

Proximate composition (%)	Fish species		
	Catla catla	*Labeo rohita*	*Cirrhinus mrigala*
Moisture	60.31 ± 0.72 ^{ax}	65.44 ± 2.32 ^{cx}	66.02 ± 1.42 ^{cx}
	Fish from polluted area of River Chenab		
Lipids	12.04 ± 0.01 ^{by}	11.25 ± 0.21 ^{bx}	8.84 ± 0.01 ^{ax}
Proteins	13.45 ± 0.01 ^{cx}	10.39 ± 0.43 ^{by}	9.25 ± 0.01 ^{az}
Ash contents	12.61 ± 0.09 ^{by}	12.38 ± 0.59 ^{bx}	14.57 ± 0.09 ^{ax}
Carbohydrates	0.93 ± 0.03 ^{bx}	0.18 ± 0.01 ^{az}	0.84 ± 0.09 ^{by}
	Farmed fish		
Moisture	68.16 ± 0.42 ^{ay}	70.60 ± 0.02 ^{by}	73.04 ± 0.02 ^{cy}
Lipids	5.04 ± 0.01 ^{ax}	6.41 ± 0.01 ^{ay}	8.86 ± 0.43 ^{cx}
Proteins	14.12 ± 0.01 ^{cy}	12.05 ± 0.09 ^{bz}	7.19 ± 0.09 ^{ax}
Ash contents	11.74 ± 0.15 ^{ay}	10.28 ± 0.11 ^{by}	8.61 ± 0.16 ^{cz}
Carbohydrates	0.72 ± 0.11 ^{ax}	0.58 ± 0.05 ^{bx}	1.00 ± 0.18 ^{cy}
	Fish from upstream area of River Chenab		
Moisture	64.93 ± 0.22 ^{az}	68.52 ± 2.36 ^{az}	70.92 ± 1.42 ^{bz}
Lipids	8.61 ± 0.01 ^{az}	7.40 ± 0.01 ^{cy}	9.52 ± 0.01 ^{bx}
Proteins	14.73 ± 0.01 ^{by}	13.72 ± 0.74 ^{bz}	10.73 ± 0.31 ^{ay}
Ash contents	9.41 ± 0.23 ^{ax}	8.25 ± 0.31 ^{bz}	7.66 ± 0.10 ^{cz}
Carbohydrates	1.22 ± 0.16 ^{cy}	0.49 ± 0.04 ^{ax}	0.32 ± 0.19 ^{ax}

Means for particular parameter sharing similar letters in a row (abc) or in a column (xyz) are statistically non-significant ($P > 0.05$).

the UC and PS site, respectively. Nair and Mathew (2000) reported that protein contents have varied between 15 and 21%. Aydin et al. (2013) recorded comparatively higher level of protein in *L. sceleratus*. Jakar et al. (2012) recorded protein content as 9.53, 10.11, 13.60 and 14.87% in Rohu, Catla, Pangas and Magur respectively. They were of the opinion that this variation in protein content of fish muscle of these fishes may be due to habitat variation, water quality and availability of planktonic community. The protein contents of *Labeo rohita* and *C. catla* are also in line with the findings of Arfa and Ali (2008) but not for *Cirrhinus mrigala*. The findings of this study for protein contents in fish were in agreement with the results of Ali et al. (1992). The decrease in protein contents in animals under toxic stress is due to diversification of energy to accomplish impending energy demands (Sobha et al., 2007). The carbohydrate level varied in marine and freshwater fish species as a result of heavy metal pollution (Azrina and Ismail, 2011; Fapohunda and Ogunkoya, 2006). They reported comparatively higher level of carbohydrate to this study. Carbohydrates probably contribute more like lipids to conserve as glycogen in the fish's body (Das and Sahu, 2001). According to Nath et al. (2014) the variation in the concentration of lipid was due to external (environment, culturing method, tropic effects) and internal factors (feeding regimen, life cycle, topographical origin and parts of muscle tissue). Lipid and carbohydrate contents were in line with findings of Das and Sahu (2001) and Hazara et al. (1998). Limited information is available in the literature about an effect of heavy metal contamination on proximate composition and amino acid profile of freshwater fishes and their use as a biomarker of heavy metal contamination. The findings of this research work have indicated that environmental contaminants probably had adversely affected the proximate composition of fish meat in *C. catla*, *L. rohita* and *C. mrigala* hence, more research work is required to verify these findings.

The overall maximum (0.046 ± 0.00) and minimum (0.0327 ± 0.00) total essential (EAAs) in *C. mrigala* and *L. rohita* collected from PS site was registered. The maximum (0.187 ± 0.001 and minimum (0.0657 ± 0.001) non-essential amino acids (NEAAs) were estimated in *L. rohita* and *C. catla* procured from the PS site (Table 2). Fish from the polluted sections of the River Chenab showed that there is a significant decrease in the concentration of amino acids compared to the fish from UC and FC sites (Table 2–4). Missing of some EAAs (threonine, phenylalanine, arginine, methionine and histidine) and NEAAs (tyrosine, proline and glutamic acid) in these fish species from this PS site of the river was observed. In the muscle of *C. mrigala* and *L. rohita*, there is an increase in the concentration of some non-essential amino acids such as cysteine but not in *C. catla*. The concentration of the valine was recorded more than five times higher in *C. mrigala* and *L. rohita* harvested from FC site compared to the UC and PS sites. The highest concentration of lysine was recorded in *L. rohita* closely followed by *C. catla* collected from the UC site of the River Chenab. The concentration of the lysine was significantly decreased in all the major carp fish species procured from the PS site of the river Chenab. Isolucine was found in a considerable concentration in *C. catla*, *L. rohita* and *C. mrigala* procured from the UC site of the River Chenab compared to the PS and FC sites (Tables 2–4). *L. rohita* showed its highest concentration as compared to other two fish species collected from the UC site while non-significant differences were observed for leucine among all the fish species from each habitat. Phenylalanine was found missing in *C. mrigala* and *L. rohita* collected from the PS site of the river (Table 2). *C. mrigala* showed more sensitivity in case of methionine where its concentration was decreased significantly collected from FC and PS sites. Threonine, histadine and lysine showed most important and interesting decrease in their concentration among non-essential amino acids. In case of both EAAs and NEAA collected from the UC (wild fish upstream area) site of the river fish showed comparatively reasonable concentration of the AAs (Table 3). In these three fish species collected from the PS site have arginine either missing or in least concentration. Proline was founded missing or remained undetected in all species from the polluted environment while serine was detected in least quantities.

Table 2
Amino acid profile of Indian major carps collected from the polluted area of the River Chenab (g/g of dry meat ± S.E).

Amino acid	*Catla catla*	*Labeo rohita*	*Cirrhinus mrigala*
Val	0.009 ± 0.0006a	0.003 ± 0.0004b	0.004 ± 0.0002b
Leu	0.003 ± 0.0001a	0.003 ± 0.0001a	0.0037 ± 0.0002b
Ilu	0.002 ± 0.0009a	0.003 ± 0.0007b	0.005 ± 0.0001c
Phe	0.003 ± 0.0004a	ND	ND
Met	0.008 ± 0.0003c	0.007 ± 0.0003b	ND
Thr	ND	0.0019 ± 0.0001a	0.0081 ± 0.0001b
Lys	0.003 ± 0.0004a	0.008 ± 0.0004c	0.0242 ± 0.0013b
Arg	ND	ND	0.0004 ± 0.0001c
His	0.003 ± 0.0001a	0.007 ± 0.0009c	ND
ΣEAA	0.0329 ± 0.0002A	0.0327 ± 0.0003A	0.0456 ± 0.0000B
Cys	0.0277 ± 0.0030c	0.0944 ± 0.0040ab	0.0833 ± 0.0024a
Tyr	0.0067 ± 0.0001a	0.0049 ± 0.0003c	ND
Asp	0.0216 ± 0.0041a	0.0380 ± 0.0018ac	0.0111 ± 0.0011b
Ser	0.0009 ± 0.0001bc	0.0007 ± 0.0003b	0.0001 ± 0.0000a
Gly	0.0029 ± 0.0002b	0.0057 ± 0.0004a	0.0028 ± 0.0004b
Pro	ND	ND	ND
Glu	0.0295 ± 0.0029a	0.0391 ± 0.0023ab	ND
Ala	0.0026 ± 0.0001a	0.0043 ± 0.0001b	0.0026 ± 0.002a
ΣNEAA	0.0657 ± 0.0017C	0.1871 ± 0.0013A	0.0999 ± 0.0010B

EAA; Essential amino acids, NEAA; Non-Essential amino acids. Means sharing similar letter in a row or in a column are statistically non-significant (P > 0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Table 3
Amino acid profile of Indian major carps collected upstream to the polluted area of the River Chenab (g/g of dry meat ± S.E).

Amino acid	*Catla catla*	*Labeo rohita*	*Cirrhinus mrigala*
Val	0.0088 ± 0.0017c	0.0071 ± 0.0009ab	0.0007 ± 0.0001ab
Leu	0.0042 ± 0.0007a	0.0082 ± 0.0020b	0.0041 ± 0.0001a
Ilu	0.0198 ± 0.0009a	0.0243 ± 0.0034b	0.010 ± 0.007c
Phe	0.0088 ± 0.0003c	0.0123 ± 0.0010a	0.0074 ± 0.0013b
Met	0.0104 ± 0.0010a	0.0122 ± 0.0001a	0.0114 ± 0.0001a
Thr	0.0122 ± 0.0020a	0.0181 ± 0.0021c	0.0321 ± 0.0007b
Lys	0.0433 ± 0.0026b	0.0444 ± 0.0029ab	0.0401 ± 0.0009a
Arg	0.0091 ± 0.0003b	0.0099 ± 0.0003b	0.0057 ± 0.0014a
His	0.0121 ± 0.0020a	0.0218 ± 0.0027a	0.012 ± 0.0003b
ΣEAA	0.1286 ± 0.0028A	0.1583 ± 0.0031B	0.1234 ± 0.0024A
Cys	0.0301 ± 0.0040a	0.0247 ± 0.0036b	0.0449 ± 0.0015c
Tyr	0.0126 ± 0.0010a	0.0145 ± 0.0021a	0.0014 ± 0.0004c
Asp	0.0712 ± 0.0030b	0.0691 ± 0.0031b	0.0555 ± 0.0029a
Ser	0.0030 ± 0.0009a	0.004 ± 0.0001ab	0.0013 ± 0.0007c
Gly	0.0002 ± 0.0001b	0.0030 ± 0.0001a	0.0004 ± 0.001ab
Pro	0.0031 ± 0.0001b	0.0085 ± 0.0020a	0.0066 ± 0.0006a
Glu	0.0494 ± 0.0030a	0.0511 ± 0.0029a	0.0302 ± 0.0019b
Ala	0.0283 ± 0.004ab	0.0337 ± 0.0010b	0.0188 ± 0.0000a
ΣNEAA	0.1979 ± 0.0029B	0.2085 ± 0.0014A	0.1591 ± 0.0028B

EAA; Essential amino acids, NEAA; Non-Essential amino acids. Means sharing similar letter in a row or in a column are statistically non-significant (P > 0.05). Small letters represent comparison among interaction means and capital letters are used for overall mean.

Amino acids (AAs) are the main constituent that had been used in assessing the nutritional value of the fishes (Mohammaed and Alim, 2012). Total number of AAs detected in dried meat samples of *C. catla*, *L. rohita* and *C. mrigala* were 14, 17 and 17 harvested from the PS, UC and FC site respectively. The concentration of essential amino acids (EAA) in *C. catla*, *L. rohita* and *C. mrigala* was estimated as 7, 7 and 6 g/g of dry meat, respectively in fishes collected from the PS sites from the river. The decrease in the level

Table 4
Amino acid profile of farmed Indian major carps (g/g of dry meat ± S.E).

Amino acid	*Catla catla*	*Labeo rohita*	*Cirrhinus mrigala*
Val	0.0040 ± 0.0007b	0.0243 ± 0.0011a	0.0269 ± 0.0001a
Leu	0.0044 ± 0.0003a	0.0054 ± 0.0001b	0.0048 ± 0.0001c
Ilu	0.0007 ± 0.0001c	0.0012 ± 0.0001b	0.0047 ± 0.0002a
Phe	0.0073 ± 0.0001a	0.0019 ± 0.0001b	0.0041 ± 0.0010c
Met	0.0106 ± 0.0002b	0.0063 ± 0.0009a	0.0007 ± 0.0001a
Thr	0.0039 ± 0.0001a	0.0021 ± 0.0003b	0.0030 ± 0.0000a
Lys	0.0329 ± 0.0018a	0.0099 ± 0.0003b	0.0390 ± 0.0014a
Arg	0.0077 ± 0.0001a	0.0009 ± 0.0001c	0.0071 ± 0.0005b
His	0.0041 ± 0.0001a	0.0036 ± 0.0004b	0.0022 ± 0.0001ac
ΣEAA	0.0755 ± 0.0023A	0.0556 ± 0.0004B	0.0925 ± 0.0011C
Cys	0.0564 ± 0.0022a	0.0276 ± 0.0028b	0.0215 ± 0.0016b
Tyr	0.0074 ± 0.0011b	0.0015 ± 0.0001a	0.0006 ± 0.0001c
Asp	0.0516 ± 0.0031b	0.0134 ± 0.0014c	0.0163 ± 0.0021ac
Ser	0.0061 ± 0.0001b	0.0081 ± 0.0004c	0.0022 ± 0.0007a
Gly	0.0041 ± 0.0073a	0.0063 ± 0.0001c	0.0013 ± 0.0003b
Pro	0.0032 ± 0.0001a	0.0024 ± 0.0002b	0.0008 ± 0.0011c
Glu	0.0395 ± 0.0014b	0.0217 ± 0.0013a	0.0041 ± 0.0006b
Ala	0.0037 ± 0.0004c	0.0026 ± 0.0003a	0.0028 ± 0.0002a
ΣNEAA	0.1720 ± 0.0026A	0.0836 ± 0.0010B	0.0496 ± 0.0011C

EAA; Essential amino acids, NEAA; Non-Essential amino acids. Means sharing similar letter in a row or in a column are statistically non-significant ($P > 0.05$). Small letters represent comparison among interaction means and capital letters are used for overall mean.

of EAAs in these fish species from the polluted site was due to contamination of the river due to anthropogenic activities. Lysine in fish meat showed interesting behavior in its concentration in contaminated water bodies (Ali et al., 1992) in polluted area fishes. Ali et al. (1992) reported heavy metals may inhibit intestinal absorption of essential amino acids like methionine and lysine in fish. Lysine is considered as a limiting EAA in many protein sources used in fish feeds (Mohammaed and Alim, 2012). The decrease in its concentration was due to environmental degradation in these fish species may become a limiting factor for those using fishmeal as a major ingredient for the preparation of a balanced fish and poultry feed. Among non-essential amino acids, the cysteine showed an increase in concentration in *C. mrigala* and *L. rohita* (Sobha et al., 2007) but not in case of *C. catla* contradicting the findings of (Azrina and Ismail, 2011; Fapohunda and Ogunkoya, 2006; Shah, 2017). Pollution associated increase in cysteine and its biological effects on fish can be understood in the context of its relationship with metallothioneins and methionine. Metallothioneins (MTs) are cysteine-rich and heat-stable proteins that bind to metals through metal–thiolate bonds (Hussain et al., 2017). Such cysteine-rich proteins, forming a distinctive set of protein frameworks and folds, are found in all living organisms and often play crucial roles as growth factors, hormones, ion channel modulators and enzyme inhibitors in various biological pathways (Lavergne et al., 2012). Metal pollution, therefore, may provoke an increased demand for cysteine so as to support the synthesis of MTs but this cysteine demand is unlikely to be met from the diet. As a nonessential amino acid, however, cysteine can be synthesized from its essential amino acid precursor, methionine (National Research Council, 2011). Aspartic acid, Glutamic acid, alanine and tyrosine concentration were decreased in fish harvested from polluted area of the river compared to farmed and non-polluted sites indicating a clear impact of pollution. Tyrosine was found in the least amount in *C. mrigala* followed by *L. rohita* and *C. catla*. The highest total amino acid concentration was recorded in *C. catla*, followed by the *L. rohita* and *C. mrigala* (Table 4). Studies have also confirmed, however, that sufficient levels of methionine are required for optimal growth, feed efficiency, survival and nutrient utilization, and therefore the reduction in methionine to support cysteine and thence MT synthesis in an attempt to cleanse pollutants has a knock-on effect in terms of retarded growth and increased mortality (Mdar et al., 2012). Although, these are the most popular fish species in the country, but due to continuous water pollution of the river made it unsuitable for use as nutritive principles for manufacturing fishmeal, because it may not stimulate either growth of cultured fishes or poultry due to their low ratios of AAs (Das and Sahu, 2001; Nath et al., 2014). Significant differences were reported in amino acid profile of fish species collected from the varying degree of polluted environments (Das and Sahu, 2001). Salem (2003), concluded that Cd and Pb negatively affected fish body gain, protein efficiency ratio, chemical composition and muscle area. Based on their known toxicological profiles in many animal models, it is certainly plausible that waterborne metals could alter physiological and biochemical parameters in fish (Abedi et al., 2013 Kaleshkumar et al., 2017).

4. Conclusion

It has been concluded a loss in the nutritional value in fish harvested from the polluted environment of the River Chenab was because of missing of certain amino acids. The fish harvested from mildly polluted areas did not show any significant loss in their nutritional values. This fact is even more important if we consider wild fish best in terms of nutritional value, especially for protein. It is proposed that an interest in commercial fish culture must be increased to fill up the gaps between demand and the supply with better nutritive production of Indian major carps. The proximate composition and AAs profiles of fish harvested from the polluted area of the river clearly indicated that efforts should be made for the restoration of habitat to meet a demand for high quality fish meat at low cost.

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Conflict of interest

None to declare.

Ethical guidelines

The standard guidelines for animal experiments prepared by the department and the university were followed in this study.

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