

# Protein and mineral contents in some fish species available in the Brahmaputra river of Bangladesh

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## ABSTRACT

An experiment was conducted in the laboratory of the Department of Agricultural Chemistry, Bangladesh Agricultural University (BAU), Mymensingh to determine protein and major mineral nutrients (viz. Ca, Mg, Na, K, P, S and Fe) in different available fish species of the Brahmaputra river of Bangladesh. Total 32 fish samples of 15 fish species were collected from three locations (viz. Bhabakhali bazar, BAU campus and Mymensingh town) of the Brahmaputra river during November 2017. The highest amount of Ca (2.00%), Mg (4.17%), Na (0.41%), K (3.24%), P (0.17%), S (0.129%) and Fe (226.9 mg kg<sup>-1</sup>) were obtained from the *chela* (*Salmophasia bacaila*), *chanda* (*Chanda nama*), *chingri* (*Macrobrachium sp.*), *shingi* (*Heteropneustes fossilis*), *bele* (*Glossogobius giuris*), *baim* (*Macrornathus aculeatus*) and *mola* (*Amblypharyngodon mola*), respectively and the sequence of the mineral nutrients was K > Mg > Ca > Na > P > S > Fe. The study results revealed that out of 15 fish species, 3, 11 and 12 species can contribute 100% of Ca, Mg and K requirement for human by taking 100g fish flesh, respectively. The maximum content of N (3.88%) was obtained from *shingi* (*Heteropneustes fossilis*), while the minimum (2.81%) was recorded from *mola* (*Amblypharyngodon mola*). The protein content among the fish samples varied between 17.6-24.3% with a mean value of 21.2%. Finally, the study concluded that the common fishes available in the Brahmaputra river are a good source of protein and major mineral nutrients, which contributes in nutrition to the local people of the country.

**Keywords:** Protein, minerals, fish species, the Brahmaputra river, Bangladesh

## 1. INTRODUCTION

Fish is commonly found in natural water bodies and well known for its superior nutritional quality with a very good supply of essential minerals [1-3]. Furthermore, fishes found in river are very popular in Bangladesh. A few years ago, fishes available in natural water bodies were the major consumed protein sources of people in this country, as they were easily accessible, less expensive, culturally acceptable and can be purchased in small quantities [4]. But nowadays, discharge of industrial wastewater/ effluents into river, canal or other surface water bodies without any treatment is the common scenario in Bangladesh [5-9]. These wastewater/ effluents contained metals and other toxic substances [10-14], which often lead to decrease in number of fish species in rivers and canals of Bangladesh.

However, mineral elements are essential for the normal maintenance of the human body, and these elements are mainly provided to the body through dietary intake. The human being may suffer from diseases like anaemia, osteoporosis, goitre, stunted growth and

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34 genetic disorders due to insufficient dietary intake of minerals [15-17]. The World Health  
35 Organisation reported that about 2 billion of the world's population is suffering from mineral  
36 and vitamin deficiencies and the majority of these are in the third world countries [18].  
37

38 Surface water fishes are a great resource which is easily accessible to low income people  
39 and vulnerable communities prone to nutrient deficiency diseases. Nowadays mineral  
40 supplementation and food fortification are the strategies used for mitigating nutritional  
41 deficiencies but unsustainable especially for developing countries [15]. On the other hand,  
42 food based strategies are considered very much effective as well as sustainable for  
43 mitigating mineral and nutritional deficiencies. Fish can play a big role for this strategy  
44 because it can provide a variety of nutrients, including essential elements to the body [3].  
45 Minerals commonly found in fish flesh are sodium, potassium, calcium, magnesium,  
46 phosphorus, sulphur, iron, zinc and iodine [19-20]. These mineral elements participate in  
47 several biochemical reactions, viz. calcium, magnesium and phosphorus are crucial in the  
48 formation of bones and teeth; sodium and potassium work together in the transmission of  
49 nerve impulses and keeping electrolyte balance; zinc is mostly found as a cofactor in  
50 enzyme reactions, iron forms part of the haemoglobin molecule which transport oxygen  
51 around the body [21]. But there are published reports that the nutritional quality of fish  
52 depends on their species, age, size, feed and water quality [22-25].  
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54 The Brahmaputra is one of the major rivers in Bangladesh, which provide a variety of  
55 different fish species to the local people of the country. In the meantime, a total of 67 finfish  
56 species including 63 indigenous and 4 exotic/alien species have been recorded from the  
57 Brahmaputra river belonging to 46 genera, 24 families and 8 orders [26]. Considering the  
58 fact stated above, this study was undertaken to quantify the protein and mineral contents in  
59 common fish species found in the Brahmaputra river and identify the species with high  
60 protein and mineral contents which can be recommended for consumption in combating  
61 mineral and protein deficiencies of the people in Bangladesh.  
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## 63 **2. MATERIAL AND METHODS**

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### 65 **2.1 Study Area**

66 The Brahmaputra river is an antecedent, snow fed, and large trans-Himalayan river  
67 originating in southern Tibet (China). Geologically, the Brahmaputra is the youngest of the  
68 major rivers of the world and unique in many respects. It runs for a length of 2880 km and its  
69 river system drains parts of China, Bhutan, India and Bangladesh [27]. However, total 32 fish  
70 samples of 15 fish species were collected from three locations (viz. *Bhabakhali bazar*, BAU  
71 campus and Mymensingh town) of the Brahmaputra river. Details about the fish species  
72 along with their sampling locations are presented in Table 1 and Fig. 1, respectively.  
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### 74 **2.2 Collection of Fish Samples**

75 A reasonable amount (500 g to 1.0 kg) of fish samples were purchased directly from the  
76 aforementioned locations of the river system, and requisite amount of samples were brought  
77 to the laboratory of the Department of Agricultural Chemistry, BAU, Mymensingh and  
78 processed for subsequent experiment.  
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### 80 **2.3 Processing of Fish Samples**

81 After collection, scales of fish samples were removed and cleaned first. Then the fish  
82 samples were separated into edible part and non-edible part. After separation, edible part of  
83 fish samples were sun dried for 2 days, and then the samples were oven dried at 50-60°C  
84 for another 2-3 days until a constant weight was obtained. After drying, the samples were  
85 ground well with the help of mortar and pestle, and then the powdered samples were  
86 preserved in polythene bags with appropriate marking for further chemical analyses.



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88 **Fig. 1. Map shows the sampling sites of collected fish samples from the Brahmaputra**  
89 **river of Bangladesh**  
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#### 91 **2.4 Preparation of Extract of Fish Samples**

92 Powdered fish samples were used to prepare extract for the determination of different  
93 mineral nutrients. Extract was prepared by wet oxidation method using di-acid mixture [28].  
94 In this method, approximately 0.5 g of finely ground samples were taken into a 250 mL  
95 conical flask and 5 mL of di-acid mixture ( $\text{HNO}_3:\text{HClO}_4 = 2:1$ ) was added to it. Then the flask  
96 was placed on an electric hot plate for heating at 180-200°C temperature until the solid  
97 particles disappeared and white fumes were evolved from the flask. Then, it was cooled at  
98 room temperature, washed with distilled water and filtered into 100 mL volumetric flask  
99 through filter paper (Whatman No. 1). Finally, the volume was made up to the mark with  
100 distilled water and preserved for the determination of major mineral nutrients in the fish  
101 samples.  
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#### 103 **2.5 Determination of Nitrogen and Protein**

104 Total nitrogen content of the fish samples was determined by Kjeldahl method by digestion  
105 with concentrated  $\text{H}_2\text{SO}_4$  and digestion mixture ( $\text{K}_2\text{SO}_4:\text{CuSO}_4:\text{Selenium powder} = 100:10:1$ )  
106 and then distilling with 40% NaOH. The ammonia distilled over was absorbed in boric acid  
107 indicator and titrated against 0.05N  $\text{H}_2\text{SO}_4$  [29]. The % N in edible parts of fish sample was  
108 calculated by using the following formula-

$$\% N = \frac{(T - B) \times N \times 1.4}{W}$$

109 Where, T = Actual titration reading (mL); B = Blank titration reading (mL); N = Normality of  
 110 H<sub>2</sub>SO<sub>4</sub> and W = Sample weight in g. The crude protein % was calculated by multiplying the  
 111 total nitrogen % with a factor of 6.25.

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**Table 1. Details of fish samples collected from three locations of the Brahmaputra river, Bangladesh**

SL. No.	Bengali name	English name	Scientific name	Sampling location*			Total
				Bhabakhali bazar	BAU campus	Mymensingh town	
1.	<i>Punti</i>	Ticto barb	<i>Puntius ticto</i>	1	1	1	3
2.	<i>Tengra</i>	Striped dwarf catfish	<i>Mystus vittatus</i>	-	1	1	2
3.	<i>Bele</i>	Tank goby	<i>Glossogobius giuris</i>	1	1	1	3
4.	<i>Bangna</i>	Reba	<i>Labeo ariza</i>	1	1	-	2
5.	<i>Baim</i>	Zig-zag eel	<i>Macrognathus aculeatus</i>	-	1	1	2
6.	<i>Shingi</i>	Stinging catfish	<i>Heteropneustes fossilis</i>	-	1	1	2
7.	<i>Kalibaush</i>	Orange-fin labeo	<i>Labeo calbasu</i>	1	-	1	2
8.	<i>Mola</i>	Mola carplet	<i>Amblypharyngodon mola</i>	1	1	-	2
9.	<i>Chela</i>	Silver razor-belly minnow	<i>Salmophasia bacaila</i>	1	-	1	2
10	<i>Kaikka</i>	Garfish	<i>Xenentodon cancila</i>	1	-	1	2
11	<i>Meni</i>	Gangetic leaffish	<i>Nandus nandus</i>	1	-	1	2
12	<i>Chanda</i>	Elongate glassy perchlet	<i>Chanda nama</i>	1	-	1	2
13	<i>Chingri</i>	Prawns or shrimps	<i>Macrobrachium sp.</i>	1	-	1	2
14	<i>Guizza</i> or <i>Guizza ayre</i>	Giant-river catfish	<i>Sperata seenghala</i>	1	-	1	2
15	<i>Hiralo</i> or <i>Murari</i>	Carplet	<i>Aspidoparia murar</i>	-	1	1	2
<b>Total</b>				<b>11</b>	<b>8</b>	<b>13</b>	<b>32</b>

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\* Number in the column indicates type of fish species present in that particular location

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## 2.6 Determination of Major Mineral Elements

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Among the major mineral nutrient elements, Ca and Mg were determined by titrimetrically, P and S were measured spectrophotometrically (660 and 425 nm absorbance wavelength, respectively; T60 UV-Visible Spectrophotometer, PG Instrument, UK) and Na and K were estimated by flame photometrically (589 and 766 nm emission wavelength, respectively; 0.2 ppm limit of detection; Jenway PFP7, Flame Photometer, UK) [28]. Determination of Fe in the fish extracts was done by atomic absorption spectrophotometer (AAS) using a Fe hollow cathode lamp operating at 248.3 nm as the radiation source and the lamp current was set at

126 15 mA. The instrumental parameters were adjusted according to the manufacturer's  
127 recommendations.

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## 129 **2.7 Data Recorded and Statistical Analysis**

130 Data on protein and different mineral element content of fish samples were measured thrice  
131 and the mean value was recorded for presentation. Finally, obtained data were analysed  
132 statistically with the help of computer package M-STAT. Single factor ANOVA at  $P \leq 0.05$   
133 significant level was applied to compare concentrations of minerals and proteins among the  
134 fish species.

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## 136 **3. RESULTS AND DISCUSSION**

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### 138 **3.1 Mineral Nutrients Status in Different Fish Species**

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#### 140 **3.1.1 Calcium (Ca)**

141 Calcium is an essential macronutrient element, which is important for bone formation.  
142 Fishes, particularly small fishes are known to be a good source of this mineral [3-4, 30]. The  
143 minimum and maximum concentration of Ca in fish samples were 0.16% in *shingi* and 2.00%  
144 in *chela*, respectably where the mean of Ca concentration was 0.80% (Fig.1). The Ca  
145 concentration in fishes was in the sequence of *chela* > *chingri* > *bele* > *meni* > *kaika* =  
146 *bangna* > *punti* > *chanda* = *baim* = *guizza ayre* > *hiralo* > *kali baush* > *tengra* > *mola* =  
147 *shingi*. The recommended daily intake (RDI) of calcium for adults is 1000-1300 mg [18]. For  
148 the poor households in Bangladesh, cereals contributed 27.3% of the total Ca intake  
149 followed by fish (21.8%), vegetables (14.0%), and milk and dairy products (10.6%). In case  
150 of non-poor households, the contribution of cereals, fish, vegetables, and milk and dairy  
151 products was 27.3%, 21.7%, 14.9%, and 10.6% of the total Ca intake, respectively [31].  
152 Present study results revealed that in most cases higher amount of Ca was present in  
153 different available fish species collected from the Brahmaputra river of Bangladesh  
154 compared to past studies in different countries of the world and FAO measured  
155 concentrations (Table 2). The higher calcium concentrations obtained in this study may be  
156 attributed from higher levels of calcium in their feeds, and therefore more trophic transfer  
157 and accumulation of this mineral in fish flesh. However, it is also suggested that small fish  
158 with bones may be an important source of Ca in human diets [30].

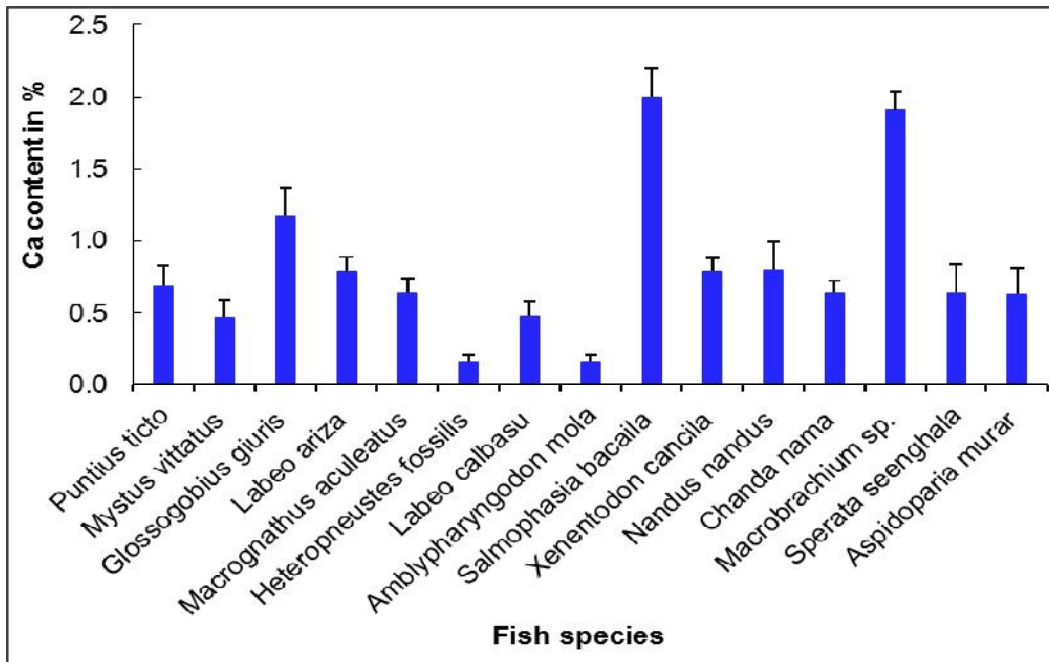
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#### 160 **3.1.2 Magnesium (Mg)**

161 Magnesium content in different available fish species collected from the Brahmaputra rive of  
162 Bangladesh ranged from trace to 4.17% (Fig. 2). The highest amount of Mg was obtained  
163 from *chanda* (4.17%) followed by *mola* (2.54%), *chela* (2.52%) and *chingri* (1.59%), which  
164 may be a very good source of Mg for human nutrition. On the other hand, trace amount of  
165 Mg was obtained from *baim* and *kaikka* fishes. The recommended daily intake of magnesium  
166 for adults is 220-260 mg [18]. So, it can be inferred from this result that 11 fish species  
167 (except *tengra*, *guizza ayre*, *baim* and *kaikka*) can contribute 100% of this requirement by  
168 taking 100g fish flesh portion. Comparison to other past studies, the present work obtained  
169 much higher magnesium content in most of fish species (Table 2). The concentration of Mg  
170 in the muscles of perch from a Siberian pond (Russia) was 136 mg in 100g<sup>-1</sup> dry weight [32].  
171 The mean value of Mg in fish samples ranged 29-41 mg 100g<sup>-1</sup> [33] and 36.4 mg 100g<sup>-1</sup>  
172 [22]. Similarly, present study results also revealed that out of 15 fish species, 12 samples  
173 contained higher amount of Mg compared to past studies conducted in different countries of  
174 the world (Fig. 2 and Table 2). This could be due to the difference of species, seasons, area  
175 of catch, feed and many other physical and environmental conditions of the area.

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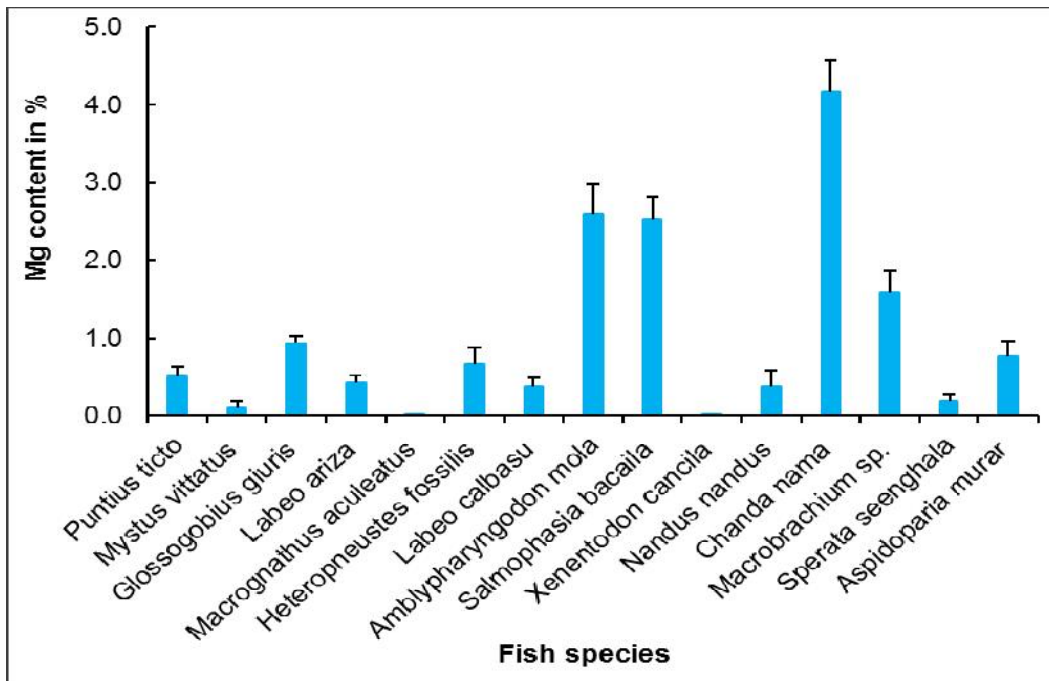


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178 **Fig. 2.** Calcium content (%) in different fish species collected from the Brahmaputra  
 179 river of Bangladesh. Each value is the mean for three replicates, and vertical  
 180 bars indicate the standard errors.

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184 **Fig. 3.** Magnesium content (%) in different fish species collected from the  
 185 Brahmaputra river of Bangladesh. Each value is the mean for three  
 186 replicates, and vertical bars indicate the standard errors.

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**Table 2. Comparison of mineral concentrations range (mg 100g<sup>-1</sup>) in fresh water fishes of this work with past studies in abroad.**

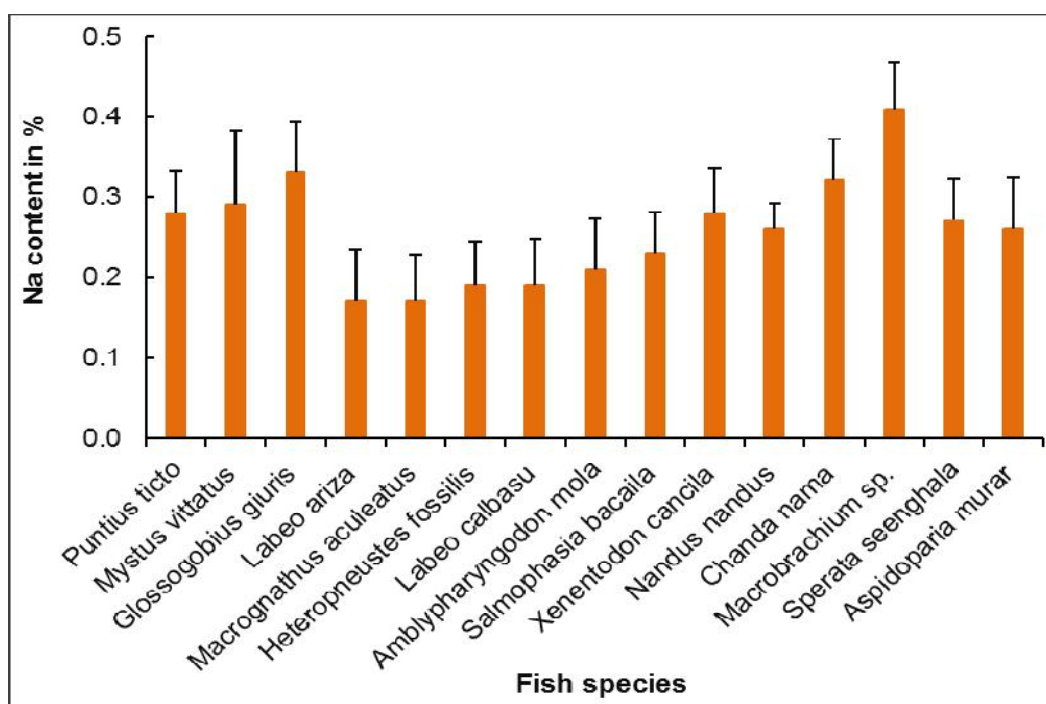
Mineral element	Lagoon in USA <sup>a</sup>	River in Pakistan <sup>b</sup>	Lake in Ethiopia <sup>c</sup>	Lagoon in Botswana <sup>d</sup>	Lake in Poland <sup>e</sup>	River in Sudan <sup>f</sup>	Rivers in India <sup>g</sup>	Present study	FAO <sup>h</sup> conc. in fish muscles	RDA (mg/day) for Indians <sup>i</sup>
Ca	760-2200	33-1080	124-981	413-1290	53-103	107-588	220-2023	160-2000	19-881	600-1200
Mg	27-140	81-156	60-81	34-48	84-143	68-75	74-120	5-4170	4.5-452	540-1002
Na	36-400	85-163	163-210	86-145	148-328	180-280	87-107	170-410	30-134	1100-3300
K	nd	282-371	1121-1728	245-443	1429-2387	954-1210	24-132	320-3240	19-502	1875-5625
P	nd	969-1730	25-56	435-1375	1047-1261	727-935	nd	60-170	68-550	600-1200
S	nd	nd	nd	nd	nd	nd	nd	95-129	130-257	nd
N	nd	11987-12736	2397-2760	nd	nd	9568-12656	958-4198	2810-3880	2400-3200	nd
Fe	2.3-9.0	2.5-7.4	1.6-2.6	1.7-6.4	0.8-1.1	1.7-6.1	7.9-24.7	0.04-22.7	1.0-5.6	17-35

190 <sup>a</sup>(USA)= Moeller et al. [36]; <sup>b</sup>(Pakistan)= Jabeen et al. [37]; <sup>c</sup>(Ethiopia)= Teame et al. [38]; <sup>d</sup>(Botswana)= Mogobe et al. [24]; <sup>e</sup>(Poland)=  
191 Luczyiska et al. [39]; <sup>f</sup>(Sudan)= Mohamed et al. [40]; <sup>g</sup>(India)= Romharsha and Sarojnalini [41]; <sup>h</sup>= FAO [34]; <sup>i</sup>= RDA [42]; nd= not  
192 determined.

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### 3.1.3 Sodium (Na)

Sodium is good for muscle functions and electrolyte balancing but it is not usually a problem in mineral deficiencies as it is frequently used to salt food [21]. Sodium content in different available fish species collected from the Brahmaputra rive of Bangladesh varied from 0.17-0.41% with a mean value of 0.26% (Fig. 3), which was more than twice as recommended by FAO (30-134 mg 100g<sup>-1</sup>) [34]. The highest amount of Na was obtained from *chingri* (0.41%) followed by *bele* (0.33%), and *chanda* (0.32%), which are a good source of Na for human nutrition. On the other hand, the lowest amount of Na was obtained from *baim* and *bangna* fishes. The muscle tissues of three species of fishes contained 381 mg Na 100g<sup>-1</sup> collected from the fresh water of Dhanmondi Lake in Bangladesh [35], which is comparable to the present study results. However, the results were at the higher end compared to some studies carried out past in freshwater fishes of other countries like USA (36-400 mg 100g<sup>-1</sup>), Pakistan (85-163 mg 100g<sup>-1</sup>), Ethiopia (163-210 mg 100g<sup>-1</sup>), Botswana (86-145 mg 100g<sup>-1</sup>), Sudan (180-280 mg 100g<sup>-1</sup>), India (87-107 mg 100g<sup>-1</sup>) and Poland (148-328 mg 100g<sup>-1</sup>). Furthermore, the Na contents obtained by this study were also higher compared to FAO reported concentrations in fish muscles (Table 2).



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211 **Fig. 4. Sodium content (%) in different fish species collected from the Brahmaputra**  
212 **river of Bangladesh. Each value is the mean for three replicates, and vertical**  
213 **bars indicate the standard errors.**

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### 3.1.4 Potassium (K)

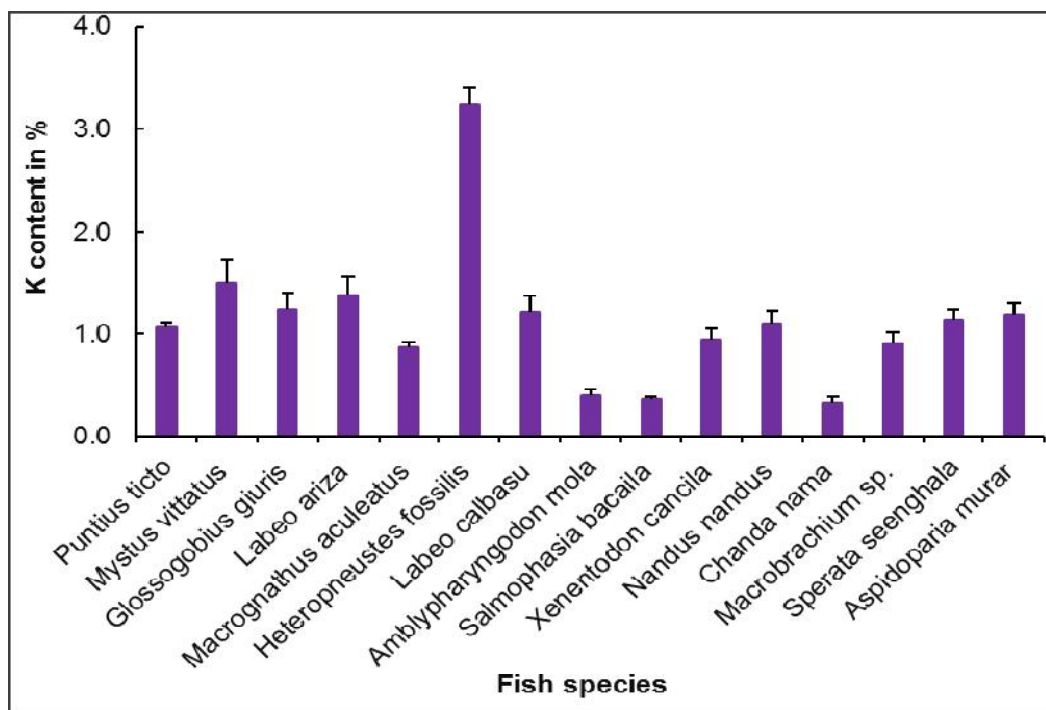
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Potassium plays also an important role like Na for muscle functions, transmission of impulses in the nerves and sugar metabolism. The highest concentration of potassium among different available fish species collected from the Brahmaputra river of Bangladesh was obtained from *shingi* fish (3.24%) and the lowest was in *chanda* fish (0.32%) (Fig. 4). The K concentration in fishes was in the sequence of *shingi* > *tengra* > *bangna* > *bele* > *kali baush* > *hiralo* > *guizza ayre* > *meni* > *punti* > *kaika* > *chingri* > *baim* > *mola* > *chela* > *chanda*. However, some studies carried out past in freshwater fishes in Turkey (321-441 mg 100g<sup>-1</sup>) [21], China (301-402 mg 100g<sup>-1</sup>) [43], Pakistan (282-371 mg 100g<sup>-1</sup>), Botswana

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224 (245-443 mg 100g<sup>-1</sup>) and India (24-132 mg 100g<sup>-1</sup>) were at the lower end compared to this  
 225 study results (Table 2). But the studies from Ethiopia, Sudan and Poland obtained much  
 226 higher K concentration levels (1121-1728, 954-1210 and 1429-2387 mg 100g<sup>-1</sup>,  
 227 respectively) which is at par with the present study (Table 2). The recommended daily  
 228 allowance (RDA) of K for males aged between 25-50 years is 800 mg [18]. So, the  
 229 consumption of 100g of this river fish flesh will provide 40-100% of the potassium daily  
 230 requirement, assuming cooking will not affect the quantity of the mineral.  
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233 **Fig. 5. Potassium content (%) in different fish species collected from the Brahmaputra**  
 234 **river of Bangladesh. Each value is the mean for three replicates, and vertical**  
 235 **bars indicate the standard errors.**

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### 3.1.5 Phosphorus (P)

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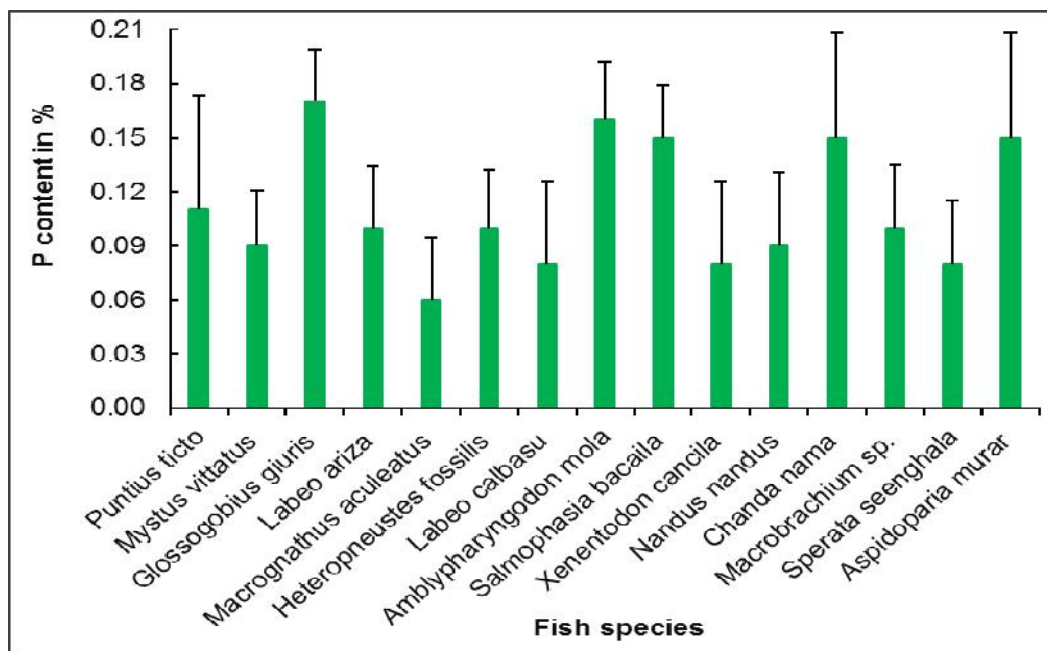
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Phosphorus as phosphate is an essential nutrient involved in many physiological processes, such as the cell's energy cycle, regulation of the whole body acid-base balance, as a component of the cell structure (as phospholipids), in cell regulation and signaling, and as a major constituents of bones and teeth [44]. The maximum concentration of P in available fish species collected from the Brahmaputra river of Bangladesh was 0.17% in *bele* fish followed by *mola* (0.16%), *chela* (0.15%), *hiralo* (0.15%) and *chanda* (0.15%). On the other hand, the minimum P concentration was 0.06% in *baim* fish (Fig. 5). The P concentration range obtained in this work was within the FAO range of 68-550 mg 100g<sup>-1</sup> sample, but the range was lower compared to previous studies conducted in Pakistan (969-1730 mg 100g<sup>-1</sup>), Botswana (435-1375 mg 100g<sup>-1</sup>), Poland (1047-1261mg 100g<sup>-1</sup>) and Sudan (727-935 mg 100g<sup>-1</sup>) for freshwater fishes. On the contrary, the range was higher compared to the past study conducted in Ethiopia (25-56 mg 100g<sup>-1</sup>) for freshwater fishes (Table 2). However, this variation of P content in different fish samples could be due to the difference of species, seasons, area of catch and many other physical and environmental conditions of the area.



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254 **Fig. 6.** Phosphorus content (%) in different fish species collected from the  
 255 Brahmaputra river of Bangladesh. Each value is the mean for three  
 256 replicates, and vertical bars indicate the standard errors.

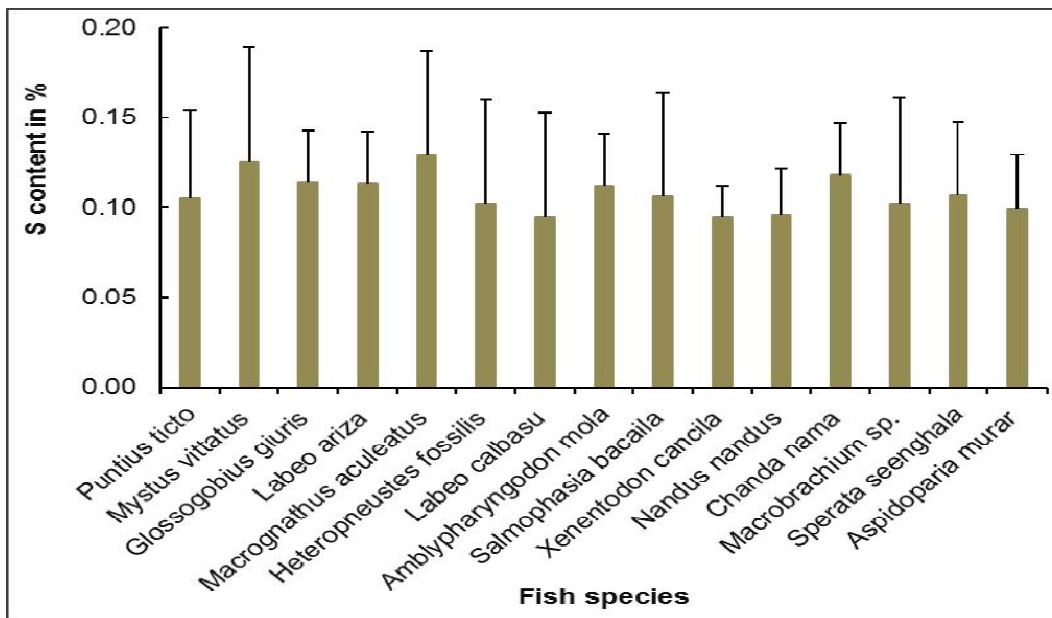
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 258 **3.1.6 Sulphur (S)**

259 The minimum S content (0.095%) in available fish species collected from the Brahmaputra  
 260 river of Bangladesh was obtained from *kali baush* fish, while the maximum (0.129%) was  
 261 found in *baim* fish (Fig. 6). Sulphur concentration range obtained in this study was at the  
 262 lower end of FAO reported range of 130-257 mg 100g<sup>-1</sup> sample (Table 2). Similarly, S  
 263 content in some important fish species of Bangladesh ranged from 160 to 300 mg 100g<sup>-1</sup>  
 264 sample [45]. However, such variations in mineral concentrations in different fish samples  
 265 could be due to the difference of species, seasons, area of catch and many other physical  
 266 and environmental conditions of the area.

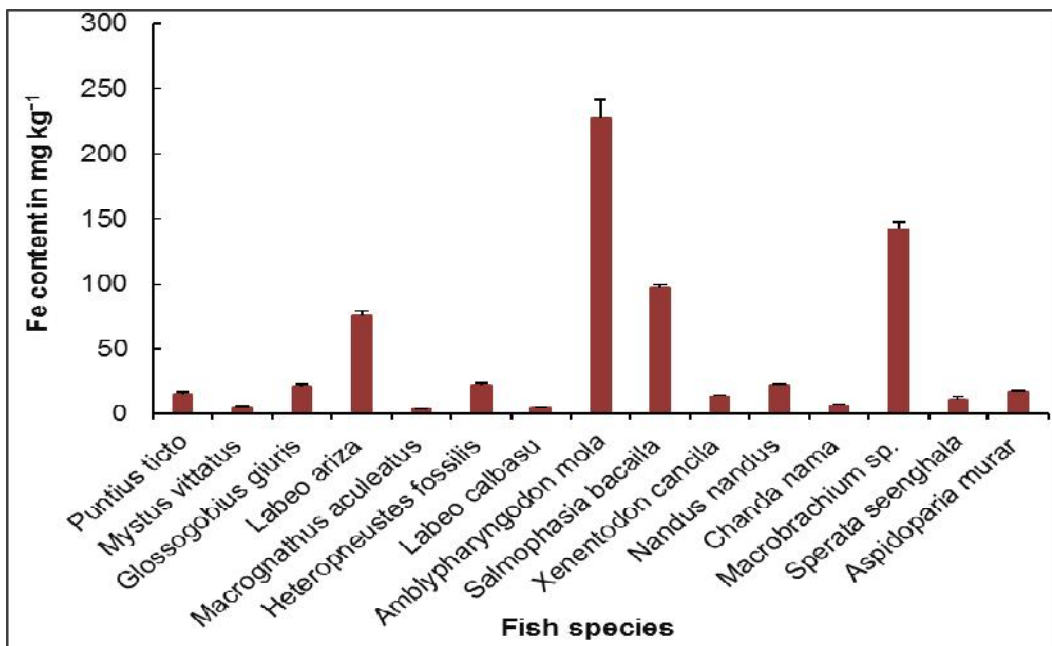
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 268 **3.1.7 Iron (Fe)**

269 Iron (Fe) is the most abundant metal in the human body. Body Fe content is approximately  
 270 3-4 g, which almost corresponds to a concentration of 40-50 mg of Fe per kilogram of body  
 271 weight [46]. Iron deficiency causes anaemia, which is one of the commonest mineral  
 272 deficiency diseases in Africa with 206 million people at risk [47]. The rich sources of dietary  
 273 Fe include red meat, liver, lentils, beans, peas, nuts, seeds, poultry, fish, seafood, leafy  
 274 vegetables, watercress, tofu, chickpeas, black-eyed peas, blackstrap molasses, fortified  
 275 bread, and fortified breakfast cereals [48]. The average concentration of Fe in different fish  
 276 samples collected from the Brahmaputra river was 44.79 mg kg<sup>-1</sup>. The minimum and  
 277 maximum concentrations of Fe in fish samples were 0.40 (*baim*) and 226.92 (*mola*) mg kg<sup>-1</sup>,  
 278 respectively (Fig. 7). The highest amount of Fe was obtained from *mola* followed by *chingri*  
 279 and *chela* that might be due to contribution of fish bone. It is worth mentioning here that  
 280 these three fish samples were processed for digestion along with exoskeleton and bone.  
 281 Furthermore, in most cases these fish species also consumed by the people along with  
 282 exoskeleton and bone. The mean Fe contents in muscle of red mullet ranged from 8.93-  
 283 49.30 mg kg<sup>-1</sup> (wet wt.), whereas levels in the liver of the same species ranged from 83.90-  
 284 889.00 mg kg<sup>-1</sup> (wet wt.). The differences between two tissues were not that significant in

285 whiting and found 21.90-160.00 mg kg<sup>-1</sup> (wet wt.) in the muscle and 49.90-328.00 mg kg<sup>-1</sup>  
 286 (wet wt.) in the liver tissues [49].  
 287



288  
 289 **Fig. 7.** Sulphur content (%) in different fish species collected from the Brahmaputra  
 290 river of Bangladesh. Each value is the mean for three replicates, and vertical  
 291 bars indicate the standard errors.  
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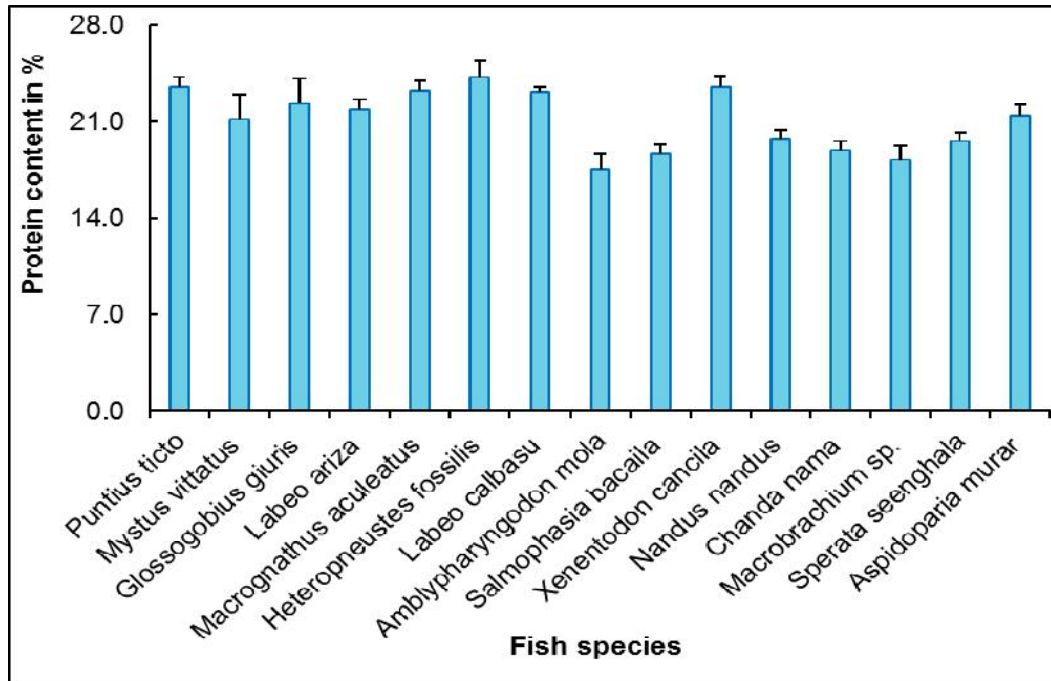
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 295 **Fig. 8.** Iron content (%) in different fish species collected from the Brahmaputra  
 296 river of Bangladesh. Each value is the mean for three replicates, and vertical  
 297 bars indicate the standard errors.

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### 3.2 Nitrogen and Protein Status in Different Fish Species

The highest concentration of N among different available fish species collected from the Brahmaputra river of Bangladesh was obtained from *shingi* fish (3.88%) and the lowest was in *mola* fish (2.81%). The mean N concentration among the fish samples was 3.39%. The N content in fishes was in the sequence of *Shingi* > *kaikka* > *punti* > *baim* > *kali baush* > *bele* > *bangna* > *hiralo* > *tengra* > *meni* > *guizza ayre* > *chanda* > *chela* > *chingri* > *mola*. However, the dry matter content of different fish species collected from fresh water examined averaged  $2.17 \pm 2.93\%$  nitrogen [50]. Nitrogen content in different available fish species collected from the Brahmaputra river was comparatively higher, which contributed to higher protein content.

Fish protein provides a good combination of amino acids which is highly suited to man's nutritional requirements and compares favourably with that provided by meat, milk and eggs. Fish protein showed a high biological value, comparable with that of milk, as shown by the similar values for apparent N absorption and N retention at each protein level [30]. In addition aquatic protein is highly digestible and rich in several peptides and essential amino acids that are limited in terrestrial meat proteins, as for example methionine and lysine [51]. The maximum amount of protein in available fish species collected from the Brahmaputra river of Bangladesh was 24.27% in *shingi* fish followed by *kaikka* (23.59%), *punti* (23.52%), *baim* (23.31%) and *kali baush* (23.19%). On the other hand, the minimum amount of protein was 17.53% in *mola* fish. The amount of protein in fish muscle is usually somewhere between 15-20%, but values lower than 15% or as high as 28% are occasionally met with in some species. However, the amount of protein obtained by this study was within the range.



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**Fig. 9.** Protein content (%) in different fish species collected from the Brahmaputra river of Bangladesh. Each value is the mean for three replicates, and vertical bars indicate the standard errors.

327 **4. CONCLUSION**

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329 Present study provides data on major mineral nutrients viz. Ca, Mg, Na, K, P, S and Fe in  
330 different fish samples collected from the Brahmaputra river of Bangladesh. Study results  
331 revealed comparatively higher amount of Ca, Mg, Na and K in different available fish species  
332 collected from the river compared to some other studies carried out in different countries of  
333 the world for freshwater fishes. The study results found that 3, 11, 12 fish species can  
334 contribute 100% of Ca, Mg and K requirement by taking 100g fish flesh, respectively. On the  
335 other hand, average consumption of 100g of this river fish flesh will provide 80-100% of the  
336 daily requirement of Ca, Mg and K, assuming cooking will not affect the quantity of the  
337 minerals. Thus the study inferred that fishes of the Brahmaputra river are a good source of  
338 protein and minerals, which contributes in nutrition to the local people of the country. The  
339 information generated from this study could be used as a baseline data for developing food  
340 composition database of the country. Finally, the study concluded that the variation of major  
341 mineral nutrient contents in different fish samples collected from the Brahmaputra river due  
342 to the difference of species, age, area of catch, feed, quality of water and many other  
343 physical and environmental conditions of the area.

344

345 **COMPETING INTERESTS**

346

347 Authors have declared that no competing interests exist.

348

349 **AUTHORS' CONTRIBUTIONS**

350

351 'Author MSAE' collected samples, performed analysis and wrote the first draft of the  
352 manuscript. 'Authors HMZ and QFQ' designed the study, supervise the work, performed the  
353 statistical analysis and corrected the final draft of the manuscript, 'Author MSR' helped in  
354 manuscript preparation. All authors read and approved the final manuscript."

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